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ORIGINAL PAPERS

VARIATIONS IN GLASS CAUSED BY HEAT TREATMENT[1]

By A. Q. Tool and C. G. Eichlin

ABSTRACT

The exothermic and endothermic effects detectable from the forms of the heating curves of a glass vary in magnitude depending on the previous heat treatment. With many of the common glasses, these variations bear a relatively simple relation to any changes in this treatment, but with others the relationship is not so easily established. Some glasses which are exceptional in this respect have a rather high silica content. It is shown in this paper that the previous heat treatment is always the chief determining factor in these variations. It should be possible therefore to obtain considerable information relative to the treatment a glass sample has received by simply studying such curves. It should also be possible to study in the same way, the relative effectiveness of the various heat treatments which may appear desirable.

It is further shown that the density is affected by the heat treatment and in the discussion reasons are given for believing that many of the other properties of glass may be varied by the same means. In this connection some speculative views as to the nature of glass are included as aids toward explaining effects already observed and also for suggesting others which should be sought.

Introduction

It has been shown[2] that the heat treatment a glass has received affects the form of its heating curve on reheating. This occurs in that region of abnormal heat absorption commonly found near those temperatures

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. Recd. Oct. 25, 1924.

[2] *Jour. Op. Soc. Amer.*, **4**, 340 (1920); *Jour. Op. Soc. Amer. & Rev. Sci. Inst.*, **8**, 419 (1924).

usually chosen for annealing. The variations in the heating curves resulting from the different heat treatments given the glass in its manufacture are so marked that it is often possible, from a study of these curves, to determine the effectiveness of the annealing treatment. With most glasses in common use the forms of their heating curves and the changes caused by altering their heat treatments are relatively simple and easily analyzed. It is possible in such cases to show that the variations so caused are also consistent and reproducible.

Typical Heating Curves

This type of heating curve is depicted in Fig. 4. Curve 13, obtained on an original specimen of sheet glass, shows the type usually found on testing a reasonably well-annealed commercial product. Curve 14 results when the same glass is annealed much more carefully, while curve 15 is typical when the glass has been cooled very rapidly. The method employed in obtaining these curves and the possible significance of the exothermic effect at temperatures just below that corresponding to the point A

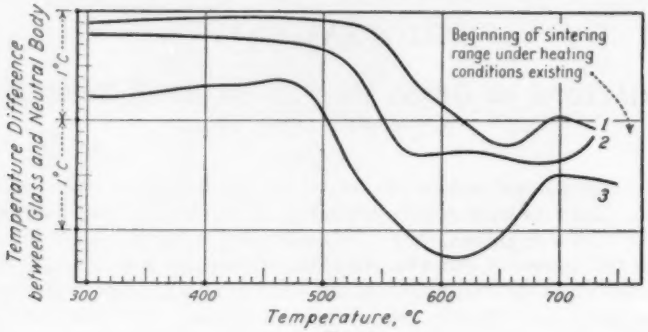

FIG. 1.

for the chilled glass and of the endothermic effect between the A and B temperatures for all three samples have been fully described and discussed in the articles noted, and consequently will not be considered in all their details in the present paper.

Consistency and Reproducibility of the Curves

It has been found in most cases[1] with glasses ranging from those used in common containers to those used for optical purposes, that neither the position nor breadth of range of the endothermic effect in a given glass varies materially under standard testing conditions (never more than a few degrees) with the character of the previous heat treatment. The differences in the form and appearance of the heating curves may be even more extreme than shown in Fig. 4 due

[1] Some apparent exceptions have been noted, of which those of light flint, light and heavy barium crown have been mentioned previously (*loc. cit.*). In the case of the barium crowns the variations were probably due to deterioration.

mostly to the changes in magnitude of the thermic effects produced through controlling the previous heat treatment of the glasses. The gradations to be obtained between the most extreme forms are also practically innumerable. In spite of this it is still easy to reproduce practically any one of these curves on any other sample of the same glass by properly re-treating it. This is usually the case even after the sample has been carried through a long cycle of chillings and annealings.

There are some glasses, however, from which it is apparently much more difficult to obtain data showing this consistency. Such difficulties are to be expected with certain opals, many enamels and glazes and similar near glasses, since they are usually incompletely vitrified or of types that

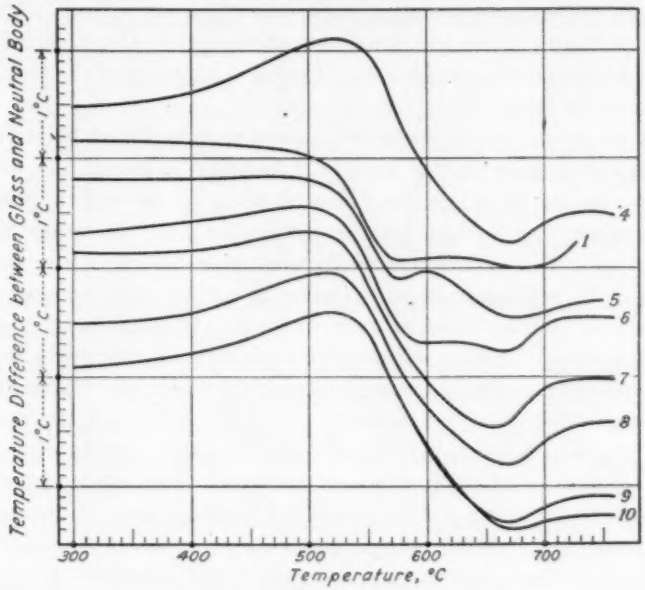

FIG. 2.

devitrify easily. Certain of the well-known real glasses also offer such difficulties, since they differ noticeably from the majority in regard to the definiteness of form of the heating curve and the simplicity of the changes caused by altering the heat treatment. Some of the glasses having a high silica content, *e. g.*, those similar to pyrex, fall in this class. With some of the glasses which show this lack of consistency, certain treatments cause a marked shift of the range of the endothermic effect. This often is accompanied, though not always, by a tendency of the glass to devitrify.[1] With others, notably some of those high in silica, the range of

[1] If devitrification actually occurs, it has been found from all previous experience practically impossible to restore the endothermic effect to the original temperature range by any heat treatment short of remelting.

the endothermic effect not only tends to shift but also to increase to abnormal widths, appearing occasionally to divide into two distinct ranges. These variations, sometimes accompanied by apparently complicated exothermic effects, often result in curves which are difficult to reproduce.

The curves shown in Figs. 1 and 2 obtained with pyrex and a somewhat similar glass of foreign make are samples of the variety of forms which such glasses yield. Although the majority of these curves were obtained with treated samples, all of them have been practically duplicated on originals. These figures show the great multiplicity of curve forms obtainable, and further tests will undoubtedly increase their number. If the changes in the curve forms are indicative of, or accompanied by, differences in the quality and the condition of the glass, these variations become of importance, since there may be quite a variation in the performance of articles made from it.

While a variation rather wider than usual may be found between different samples of a glass of this type, *i. e.*, similar to pyrex, yet, like most glasses, a number of originally different samples of such a glass when placed together in a furnace and heated to the point of sintering before receiving identical treatments, will then all give curves of practically the same form. To reproduce in any sample the condition in another yielding a certain curve form is however more difficult. It requires the equivalent of some unknown treating schedule and involves, particularly in certain ranges, the proper choice of treating temperatures and periods, and cooling rates. To do this with the majority of glasses, of which the one represented in Fig. 4 is typical, is relatively simple, since a study of the curves obtained on a series of samples whose treatment is known and has ranged from severe chilling to careful annealing[1] will usually suggest the equivalent treatment required. With certain glasses high in silica, however, this is more difficult. The experiments described below are some of those made to show that all the curve forms found on different original specimens of such a glass can be reproduced on any one of the specimens by properly treating it. They were made to determine also whether or not there was a definite permanent difference in the various specimens due to variations in the composition or to other factors, such as deterioration during use or heat treatment, etc. It appears, from experience gained during these tests, that the variations in the curve forms are for the most part due only to removable differences in the condition of the glass caused by the heat treatment received and that after sufficient data have been collected a heat treatment can be chosen which should bring the glass practically to

[1] Such a series of samples would give curves somewhat similar in appearance to those shown in Fig. 2, of the article "Certain Effects Produced by Chilling Glass," *Jour. Op. Soc. Amer. & Rev. Sci. Inst.*, **8**, 428 (1924).

any condition normally possible. These conditions are innumerable, each being determined by the "effective" annealing temperature, at which temperature the glass is probably in a state of practical equilibrium.

Experimental Methods and Results

Since the methods used in obtaining the heating curves shown here have been described fully in the references cited, it will suffice to say that they differ but little from the differential thermocouple method ordinarily used in the detection of exothermic and endothermic effects in other materials. In order to compare a number of curves obtained in this way on various specimens or samples it is always advisable to use the same heating rate and methods of packing the samples in the furnace, and also to maintain all other conditions as nearly the same as possible. This usually requires that the tests be made in sequence and that the samples be changed with a minimum disturbance of the packing and containers and obviously also with no appreciable alterations in the apparatus used.

Preparation of Sample In preparing the glass for these studies a large quantity of each specimen was broken into bits and after discarding the finer particles and larger pieces those retained averaged about 1 mm. in diameter. This prepared glass was thoroughly mixed and divided into a number of samples for the various treatments proposed.

Heating Rates The heating rates in the following tests were in all cases approximately 6.5°C per minute. The observations on the actual temperatures of the glass were taken at ten-minute intervals, intermediate temperatures being obtained by interpolation; while those necessary to determine the temperature differences between the glass and neutral body were taken at approximately 12°, 6°, or 3° intervals, depending on the rapidity with which this difference changed. Usually the heating was continued until those temperatures were reached where incipient sintering caused variations in this temperature difference. With samples of a uniform character and under standard heating and packing conditions this point is fairly definite but changing these factors alters it somewhat.

Plotting of Curves In the curves as plotted the variations in the ordinates represent the changes in the difference in temperature between the glass and neutral body, while the abscissae indicate the actual temperatures of the glass. The lines showing the trend of the curves include within their width all the points representing the observations. To prevent entanglement and to make comparison easy the curves have been shifted arbitrarily one above the other. This is permissible since it is the variation of the ordinate and not its absolute value which is of importance.

Curves for Pyrex Glass

In Fig. 1, curve 1 was obtained on the original (*i. e.*, untreated) glass from a pyrex beaker. This curve shows practically no trace of what sometimes appears to be a second heat absorption region (590° to 680°C); the first one, however, (520° to 570°C) is quite definite. In fact, no curve was obtained on pyrex in which evidence of this first absorption region was missing. Curve 2 was obtained under similar conditions on an untreated sample from a flask made from a foreign glass, high in silica and somewhat similar to pyrex in its characteristics. The two curves appear quite dissimilar; however, the latter does not differ to the same degree from other curves that have been obtained on other samples of pyrex. One of the chief differences to be observed between the two curves is that the first indication of an absorption region occurs about 20° higher in 2 than in 1. This eliminates in part the first absorption region in the former, and probably enhances the indication of a second region.

Curve 3 was obtained on this same foreign glass, after it had been heated for one hour at 700°, cooled in $^1/_2$ hour to 520°, annealed about twenty hours in the range 520° to 510°, cooled to 490°C in seven hours, and then rapidly to room temperature. This curve indicates that by this treatment the magnitude of the heat absorption has been greatly increased and that the temperature at which it begins has been reduced about 50° (to 490°C); or almost 30° lower than the temperature at which it usually begins in pyrex. It has also been found that the same treatment of pyrex produces a curve of similar form, together with a reduction of the beginning temperature of the absorption.

In Fig. 2, curve 4 was obtained on part of the specimen giving curve 1, Fig. 1 (also shown as curve 1 in Fig. 2 for comparison) after it had been heated to 765°C and chilled in water. This curve shows a pronounced exothermic effect which begins near 350° and causes the appearance of the heat absorption to be delayed until 540° is reached. Curve 5 was obtained on a sample of this chilled glass after it had been retreated by holding it for one hour at 520° and re-chilling it in air from this temperature. This curve shows no exothermic effect[1] below 500°C, but there is a slight indication of a double absorption region, as may be noted. It also resembles in many respects a large number of the curves obtained on original specimens collected from time to time. This resemblance would make it appear that the treatment given these specimens approximated the last treatment given this sample: *i. e.*, after being molded or blown they were probably cooled quite rapidly to an annealing temperature

[1] The small rise in this curve near 600°C is undoubtedly due chiefly to a tendency to wipe out the abnormal temperature difference caused by the preceding endothermic effect, although some glasses have been found which seem to show two or more regions where exothermic effects may appear.

near 520°C, annealed for a short period, and then finally cooled again rather rapidly to room temperature.

Curves 6, 7, 8 and 9 (Fig. 2), all of which have been practically duplicated by curves obtained on original specimens,[1] resulted from tests on other samples of this same chilled portion of the glass re-treated in much the same manner as the sample corresponding to curve 5: namely, after being heated for one hour at the indicated temperatures, 560°, 600°, 640°, and 680°C respectively, they were cooled rapidly in air. In curves 7, 8, and 9 the exothermic effect again becomes apparent and in the last of these it is almost as pronounced as it was before the re-treatment; consequently curve 9 differs very little from curve 4 in form. This similarity does not mean, however, that the re-treatment failed to remove the effect of the previous chilling in water, because other experiments have led to the conclusion that the effect of this first chilling was doubtless almost wholly removed before the glass reached 680° while reheating for the second treatment, and that the exothermic effect observed in curve 9 is undoubtedly due almost entirely to the air chilling in the latter treatment. This view is further substantiated by the almost identical forms of curves 9 and 10, since the latter was obtained on a sample of the original glass after it had been given only a single treatment duplicating the re-treatment given in securing the former.[2]

In Fig. 3, curves 11 and 12 (the latter resulting from a test taken immediately after that giving the former) are plotted together for the purpose of comparison, since curve 11 was obtained on a sample of the original glass while curve 12 was secured on a sample of the same glass specimen after being specially treated to bring out, if possible, the double absorption region more definitely. This special treatment consisted of holding the glass for an hour at about 700°C, cooling it at a rate of 20° per hour to 600°, then to 590° during the night and again at 20° per hour to 450°, where it

[1] As used here "original specimens" refers to the samples "as received" and does not mean that all of them were taken from new ware, since many of them were from used articles, a fact which probably accounts for some of the variations observed on testing such specimens.

[2] These two curves are a good example of the closeness with which curves on specimens of a glass in the same condition can be duplicated if testing conditions, particularly the packing, are the same. On the other hand, curve 1, Fig. 1, and curve 11, Fig. 3, both obtained on samples from the same original specimen but with several days intervening between the tests, during which time the apparatus was in almost constant use causing unavoidable, though small, changes in the packing, etc., show some of the variations that may be caused by changing the testing conditions. The differences in the latter curves, although noticeable, are not extreme and consist chiefly of a change in the magnitude of the drop (500° to 580°C) and of the return (580° to 620°). Experience based on series of consecutive tests on samples from a single homogeneous specimen shows, however, that these variations are greater than they should be with homogeneous glass, if no changes had taken place in the testing conditions.

was held over night before being cooled slowly to room temperature, and it produced, as the curve shows, the desired effect. Convenience played a considerable part in the choice of the above schedule, and undoubtedly treatments less elaborate can be devised to produce and even to enhance the effect obtained. No further attempts, however, of this kind were

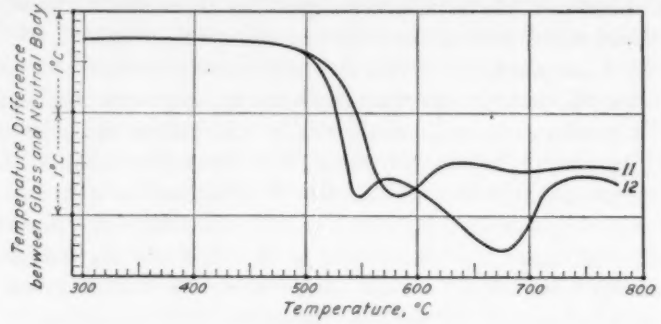

FIG. 3.

made, since this result, together with those of the preceding tests, seemed sufficient to substantiate the belief that the variety of effects observed with different specimens of high silica glasses are due chiefly to the treatments given the ware.

Curves for Window Glass

In Fig. 4 some curves for a commercial window glass are given to show the differences between the curves for high silica and ordinary glasses. Curve 13 obtained on an original specimen of this glass shows the form usually found for many of the ordinary window glasses procured on the market. A large sample of this specimen was more thoroughly annealed by holding it for 22 hours in the range 520° to 510°C and then cooling it at an increasing rate starting with about 10° per hour. Part of this sample was then retreated by heating it to 670° and chilling it in air. Curves 14 and 15 respectively were obtained on the annealed and chilled parts of the sample. The first shows a higher degree of annealing than is usually found in commercial glass, while the second shows a greater degree of chilling.

Curves for Other Glasses

In regard to the differences in the curves for the various types of glasses it will be noted that the indications of a heat absorption effect in these curves are much more distinct than in those for pyrex and that the effect is confined to a narrower range. Most other clear glasses used in containers, optical instruments, etc., when treated in the same way, give curves similar to those in Fig. 4 except that the heat absorption effects occur in widely different temperature ranges depending on the composition. Their curves are therefor simpler in form than those for pyrex. Thus, when any one of these glasses is treated in the various ways followed

in obtaining the curves shown in Fig. 2, excepting, of course, that the treating temperature must be chosen in conformity with the region of the endothermic effect, complicated curves of the type found in that figure are not secured, but instead curves like those shown in Fig. 2, page 428, of the above mentioned article, "Certain Effects Produced by Chilling Glass," result. Under some treatments, however, certain peculiarities in curve form can be obtained even with these glasses. This happens when a chilled sample is treated for a short time at temperatures below the heat absorption region. Some curves for borosilicate and light barium

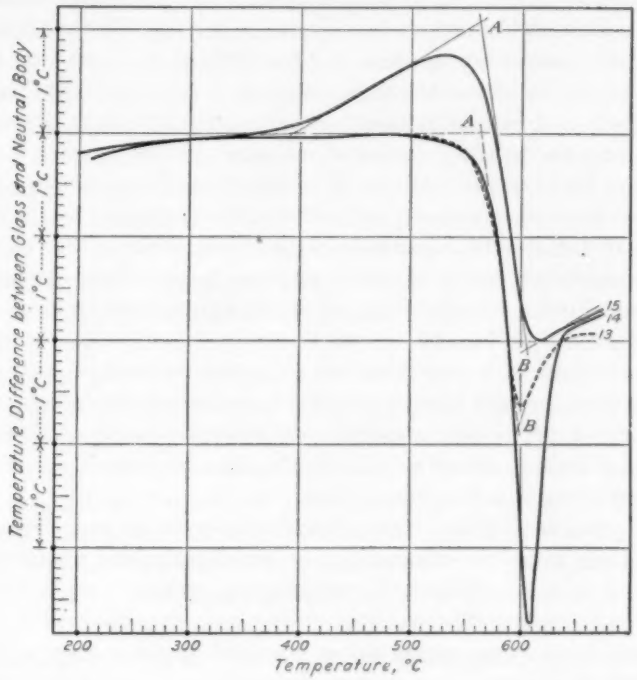

FIG. 4.

crowns having the peculiarities here referred to were shown at the 1924 meeting[1] of the AMERICAN CERAMIC SOCIETY at Atlantic City. These peculiarities of curve form appearing when such glasses are so treated are insignificant in magnitude, however, relative to those found in the foregoing curves for the high silica glasses.

Comparison of Other Glass with Pyrex

The greater width of the heat absorption range and the greater variety of curve forms obtainable with pyrex in comparison with the majority of glasses are probably due to no single cause. One of the properties of

[1] The paper presented at that meeting is now being prepared for publication.

this glass, however, which may be related to, if it does not play a conspicuous part in these differences, is the slow rate at which its mobility increases with the temperature. An increase of about 12°C in temperature is required to double the mobility in the heat absorption range, whereas from 7° to 9° is sufficient for most ordinary glasses.[1] Though this value of Twyman's coefficient found for pyrex is not particularly large or exceptional, as the work of S. English[2] shows, yet it is undoubtedly enough larger than the average to suggest the possible presence of causes which may be responsible, in a measure at least, for some of the differences observed in the heating curves. Furthermore, if this coefficient should vary somewhat within a wide heat absorption range, it is possible that such variations indicate changes which might easily effect, or be related to, some of the diversities in the form of the heating curve resulting from treatment that may be found in that region. That the mobility and its variations should modify the heating curves seems more probable when it is considered that the transformations or readjustments producing the exothermic and endothermic effects are undoubtedly hampered by the rigidity, while they at the same time probably cause changes in it. This hampering of readjustments (as was shown in a previous paper)[3] may produce phenomena similar to the undercooling and superheating observed in substances which crystallize. Such retardations to readjustment would in all likelihood produce quite distinct indications of absorption and evolution effects in both the heating and cooling curves of glass when the temperature is rapidly changed. The same readjustment when proceeding to completion during a slow cooling would produce little more than what might appear to be slight changes in the specific heat.

Another possibility which may influence the curve form is the presence of two or more types of adjustments or transformations which occur at their maximum rate in distinct temperature ranges. Such curves as No. 12 in Fig. 3 make this plausible. Granting, therefore, that different adjustments are possible in the same glass and that for their completion they require time, proper temperature conditions, etc., it may then be that some of these changes interfere with, or are necessary for, the completion of some of the others. Hence rapid cooling through, or long treatment within, certain temperature ranges may hinder, aid, or change com-

[1] No careful or extended measurements on the deformability of pyrex and its dependence on the temperature have been attempted in this laboratory, but the value given above is the result of some preliminary tests, which also indicated that its deformability around 550°C is not notably less than that for the majority of glasses showing heat absorptions near this point. Such glasses, however, usually lose their ability to sustain their own weight under standard conditions at much lower temperatures than the high silica glasses.

[2] S. English, *Jour. Soc. Glass Tech.*, **7**, 25 (1923).

[3] *Loc. cit.*

pletely adjustments which under proper conditions would occur in other ranges. The variety of heating curves obtained by altering the heat treatment of pyrex suggest this, and further, that the alterations in treatment should change the density, refractive index, durability (including solubility and resistance to chemicals), stability, etc. Such considerations point to the desirability of more thoroughly investigating those changes in the properties of glasses which may possibly be produced by such changes in treatment. In a ware like pyrex the properties in which these changes should be sought include its resistance to strain, mechanical shock and sudden changes in temperature; its resistance to chemicals and to deformation at moderately high temperatures, and also its density and expansivity.

While it has been impossible so far to make any extended study involving these qualities, yet some preliminary observations on the density of pyrex indicate that it may be changed quite decidedly by altering the heat treatment. For example, nine samples of an original specimen of this glass, the form of whose heating curve indicated an initial condition between those existing when curves 7 and 8 in Fig. 2 were obtained, were variously treated by heating at least one of them at each of six chosen temperatures for different periods ranging from $1^1/_2$ hours at the highest temperature, 750°C, to about 64 hours at the lowest, 500°, before cooling them rapidly to room temperature. In every case the density[1] after treatment was increased, the greatest difference (0.0065) occurring for those samples treated at 500°, the least (practically zero) for the one treated at 550°. The average difference (0.0027) was about 0.12% of the average original density (2.2364, with a maximum deviation of 0.03% or 0.0007). Considering the unannealed condition of the original specimen this increase in density was to be expected in view of the results found on borosilicate crown.[2]

After this test the samples were again treated together for about three days near 600°C, and cooled as before. The densities after this second treatment when compared with the values obtained after the first were all decreased with one exception, that occurring in the case of the sample previously treated at 550°. The average density was now 2.2358, with a maximum deviation of 0.0010, which is practically the original density. These two tests indicate, therefore, that the density of this glass can be definitely changed by altering the heat treatment.

In addition to the above tests some fragments of a pyrex beaker whose original density was 2.2385 were treated for about two days at 650°C after which they were found to have a density of 2.2382, showing a negligible decrease in value. This slight change can be explained on the assumption that the original density was approximately that which would

[1] This work on density was all done in collaboration with E. L. Peffer of the Capacity and Density Laboratories, of this Bureau.

[2] *Jour. Op. Soc. Amer. & Rev. Sci. Inst.*, **8**, 436 (1924).

be obtained by annealing somewhat above 600°, but lower than would result from a long treatment near 500°. In view of the character of these results it has been deemed advisable, however, to elaborate the tests considerably before drawing any more definite conclusions.

Conclusions

In conclusion it can be said that the heating curves presented here for some of the high silica glasses show definitely great modifications when the heat treatments are changed. These curves also indicate that the modifications obtainable with such glasses greatly exceed in variety those with most ordinary glasses. It appears from the preceding discussion that this greater variety of curve forms procurable with the high silica glasses may be due to such causes as the slow rate with which their mobilities change with temperature, or the presence of two or more groups or types of readjustments or transformations occurring at their maximum rates in different temperature ranges, and also the possibility that the completion of certain of these readjustments aid or interfere in the advancement of others. Moreover, it is quite possible that these causes, if they exist, are due to the high silica content. At least such effects from heat treatment are probably brought about by the greater chance, under certain conditions of composition and temperature, for the formation of certain molecules or groups of molecules. The density changes previously described indicate, at any rate, some phenomenon involving a closer molecular packing or association under long continued heat treatments, particularly in certain temperature ranges, notably below the beginning of the heat absorption.

The formation of different complex molecules or groups of molecules, if such occurs, need not involve a mixture of substances of such a type as to cause opalescence, or other visible effects resulting from inhomogeneities; since it is not necessary that either the complexes themselves or the regions occupied by various clusters of them be so large that they are even of microscopic size in order to produce the results so far discussed. Even if the aggregations cause regions of structural inhomogeneity approaching a macroscopic order, but do not produce marked optical inhomogeneities, they may still remain undetectable. If, however, there be considerable variation at the same time in the optical properties between the different regions, particularly when these regions are relatively large, opalescence, color, or lack of transparency may be produced. If there be differences in the expansivity, permanent local strains somewhat similar to those often observed around small striae may result from cooling. If certain of these regions of inhomogeneity be due to the presence of an excess of gaseous or easily volatilized constituents, under certain conditions small bubbles may even result.

In regard to the character of such possible structures very little can be definitely said. They might consist of complex molecules formed through ordinary reactions between all or some of the simple components, or they might be built up by a transformation resembling a polymerization which may occur between similar molecules containing one or more of the simple components. Whatever be the character of these transformations, some elements of the resultant glass, in some cases at least, will have the nature of, or resemble, colloids somewhat, and others crystalloids. As to those having a possible colloidal nature it is undoubtedly true that in certain glasses some of the components form aggregates of such a character that this conception must be admitted as applicable. It is also undoubtedly true that some of the components of a normal glass are in such a condition that they will, under certain circumstances, diffuse and crystallize with relative ease, and hence may be thought of as more or less crystalloid in character. In general, however, it is questionable whether real glasses in their normal condition are ever crystalline or contain crystalline structures, because glasses having an appreciable number of such structures will certainly show some evidence of them and must therefore be classed as devitrified.

A reasonable view, therefore, of the nature of glass which is in accordance with common experience seems to be that glass consists of a great number of both simple and complex components, the latter being formed from the simpler original ones. Of these, the larger, heavier components whose unwieldiness reduces the mobility and which crystallize with difficulty, if at all, either because of their small tendency to do so or because of the inability of exactly similar molecules to assume the requisite proximity and orientation, constitute the colloidal elements. The smaller components which have a greater mobility and diffusivity and a stronger tendency to crystallize comprise the crystalloidal constituents. A stable glass, therefore, would be one so made up that a preponderance of the components are colloidal in nature.

In any case, it appears that as a working hypothesis the conception of a glass as composed of a number of relatively large complex structures surrounded by a magma of the simpler components, or, if the complex aggregates or molecules are sufficiently numerous, as consisting of a framework or skeleton so formed by them as actually to enclose the simpler components, is justifiable. In the multiplicity of possible glasses all gradations between these extremes are likely to be encountered depending on the composition, treatment, etc. Under some conditions and in some temperature ranges relatively rigid materials may be dispersed in, or enclose, others which have different elasticities, or which are much more deformable, or even almost liquid. In such cases what approaches, or appears to be, a two-phase condition may arise, corresponding to that

described by Filon and Harris in their article on "The Di-Phasic Nature of Glass;"[1] and also under certain circumstances, corresponding possibly somewhat to the conditions found in celluloid and other materials of that type. One of the important inconsistencies which appears to exist between the view advanced here and the findings of the above authors is the absence in their case of an effect due to heat treatment, for it has been assumed here that certain heat treatments at least should change considerably the number or the relative proportions of the types of components. This should affect to some extent such apparent phase relations and probably the stress-optical coefficient. It is possible, however, that the re-treatment received by the glass in their experiment corresponded roughly to the original annealing process, in which case the resultant condition of the glass may have been practically that previous to this treatment. This could happen even though the glass after this re-treatment appeared to be somewhat "disannealed," as they describe it, since the state of equilibrium between the components is not of necessity affected in exactly the same manner as the stresses which result from cooling.

A result of greater import in practical glass-making which might arise if the complex aggregates formed a more or less rigid and extended cellular structure holding the more deformable components in its interstices is found in the possibility that in certain temperature ranges these aggregates, in forming and building up the structure, compress the more liquid or gaseous components which are released or not absorbed in the aggregates, causing them to diffuse outward and ultimately to collect in certain localities and possibly also on the free surfaces of the glass. These components which are in excess and ejected in this manner would undoubtedly be of the more soluble type; hence, if they should collect on the surface the apparent solubility of the glass would be greatly increased until they were removed.

These materials, if they are relatively simple in composition as assumed, should after becoming localized crystallize rather easily, possibly causing opacity.[2] If they reach the surface they would no doubt, under certain conditions, increase the tendency for the formation of crystals there whenever it is contaminated or otherwise mistreated. These effects from contamination, etc., have been observed by almost everyone working with glass and described by many investigators, for example, in the article by Y. Amenomiya on "The Devitrification Caused upon the Surface of Sheet Glass by Heat."[3] The possibility that these effects are enhanced by the

[1] *Proc. Royal Soc. London*, **103**, 561 (1923).

[2] Such an effect may be involved in the case of those enamels and opals which are less transparent toward the interior, presumably because the cooling at the surface is more rapid.

[3] *Jour. Soc. Glass Tech.*, **6**, 231 (1922).

release and ejection of elements normally within the glass seems sufficiently plausible to warrant its suggestion.

If these undesirable effects do arise in this manner, remedies may be obtained by the methods usual in any such case, *i. e.*, by correcting the composition so that there is no excess of components that can be ejected, or by so adjusting the heat treatment of the glass that little or none of the more mobile components are unincorporated in the complexes and practically none are forced or diffuse outward; or, finally, by removing the ejected materials from the surface by some chemical treatment. With the possibility just discussed, resistance to water or chemicals might often be reduced as a result of certain methods of annealing. However, if all the components are absorbed in the structure, or if only the less soluble are left in excess by the annealing, then the resistance of the glass to solvents may be expected to increase, since the association of the simple components into aggregates should ordinarily decrease the ease of their removal by solvent action.

Attention has been called above to the possibility that the changes in the condition of the glass as indicated by variations in the heating curve forms obtained after heat treatment, may involve a considerable change in many of its properties. These indications, together with the possibilities just discussed, appear sufficient to warrant a thorough investigation of the variations which may be produced in such properties as the refractive index and homogeneity of optical glass, the expansivity and constancy of volume of glass for volumetric purposes and the strength and solubility of chemical ware. It is believed that such investigations will show that these properties may be controlled to a considerable extent by the heat treatment, and that the nature of a desirable treatment will depend greatly on the composition of the glass and also on the quality whose enhancement is sought.

At any rate it has already been shown in one of the articles cited that the form of the heating curve obtained for any specimen may be used to determine the temperature at which the condition of the glass, as controlled by its composition and previous treatment, is relatively stable. That is, a temperature may be found at which a long heating will produce no change in the curve form or density although a heating at higher or lower temperatures for corresponding periods will cause such changes. To do this, an investigation of the curve forms obtained from many different heat treatments is necessary. Such an investigation also often makes it possible to determine approximately the procedure previously followed in annealing the specimen of glass.

For certain high silica glasses such determinations have been found difficult, although the results given here indicate that they are possible. They also indicate that an extended study of the heating curves should be helpful

in any investigation of the changes of the properties of these glasses with heat treatment and also in determining whether the annealing given them is satisfactory. Thus, certain of the curve forms (curves 1, 5, and 11 for pyrex and curve 13 for window glass) shown here are similar to those obtained on these commercial wares when said to be reasonably annealed for the purposes intended. Also, experience appears to show that it is usually safe to conclude that any sample of either of these glasses will be nearly as well annealed as any other sample of the same glass which yields, when tested under similar conditions, a curve of approximately the same form. It has been assumed, therefore, that these samples giving the above curves are all about equally well annealed and correspond in their general condition to the product usually put on the market. This must be qualified, however, if the sizes of the ware or specimens are too dissimilar, because of a possible wide variation in the magnitude of the stresses set up while cooling.

Curves which show the effect of severe chilling (such as 4 and 15) are never obtained on samples from reasonably well annealed commercial ware. The majority of the curves showing such extreme variations in form have been found on wares which had been in use for some time or on specimens for which annealing had been considered unnecessary.

Summary

In the foregoing a discussion is given of certain variations in form found in the heating curves obtained from glass. These variations are due to changes in the endothermic and exothermic effects caused by different heat treatments.

It is shown that these differences in the curves are relatively simple for many glasses but somewhat more complicated for others, including some of those having a rather high silica content. The greater variations produced in the curves by altering the heat treatments for the latter glasses make it more difficult to reproduce any particular one of their possible curve forms, that is, to cause the desired readjustments in the condition of the glass. It is shown, however, that this is undoubtedly possible if sufficient data are collected.

Curves are given which show that some of these glasses have two or more regions of increased heat absorption, which, as the discussion shows, is one of the probable causes for the greater changes in the curve forms. Some or all of these endothermic and exothermic effects noted appear to arise in part from phenomena similar to those of superheating and undercooling as well as from a tendency for a large or excessive number of normal transformations to occur within a restricted temperature range.

It is shown that the densities of these glasses are altered by the heat treatment, or more specifically by the choice of the treating temperature

and the length of the treatment. This is in accord with the view that glass when held at a given temperature approaches a condition of at least approximate stability which differs from that which would be attained at any other temperature.

An added discussion deals with the bearing that the changes in the curve form and in the density due to heat treatment, may have in throwing light on the possible nature and character of the processes involved in the formation of glass. The possibilities mentioned include the release and segregation of components during the cooling of the glass or while it is being annealed and otherwise treated. These effects may hasten devitrification or cause bubbles and other undesirable features, such as the collection on free surfaces of components having high solubilities and low melting points.

Attention is called to the fact that it may be possible through regulating the heat treatment to control to a greater extent than is usually attempted many of the properties of glass, among which are the solubility and resistance of chemical ware.

It also appears that frequent tests determining the form of the heating curves under carefully standardized conditions would be valuable in glass plant practice as a means of aiding in the regulation of these heat treatments and in checking the results obtained.

CASTING CONTROL[1]

By Albert C. Gerber

ABSTRACT

Casting bodies can be toned to a point of success by a proper manipulation of carefully chosen clays, with particular emphasis upon the china clays. A simple casting test will shed light on their individual casting properties. Regulation of casting salts and slip density, and the employment of grog in casting bodies offer means for a certain amount of control, but the preëminent qualifications of a good casting body are a balanced clay content and a correct ratio of clay content to non-plastics.

The purpose of this discussion is to describe the practical application of the solid casting process to sanitary ware.

Role of Ball Clays

Of those elements which make a good casting body, there is not one which exceeds in importance the proper proportioning of the clay. To have the ratio of clay to non-plastics correct is of course not enough. There must be painstaking care in the selection of clays employed, and the basis of selection should primarily be casting properties. Aside from impracticability in firing, it is well understood that any body containing only ball clay, irrespective of what the ratio of clay to non-plastics might be, would not adapt itself to successful casting. Ball clays to be sure contribute the very essential property of fluidity to a casting body, but the moment the mold has been filled, this most valuable property of ball clays, as far as casting is concerned, has largely played its part. The finely dispersed clay particles are rapidly floated toward the mold surface, upon which they build up with sufficient density to impede the passage of water from the center of the piece to the mold. Sections of uneven density result. It consequently becomes necessary to introduce into a casting body a tempering influence which will modify this behavior of ball clays. This is essentially the rôle of china clays.

The limits of these two generalizations are, however, extremely far apart, encompassing clays of widely different characters. Viscosimeter tests of ball clay slips will credit some ball clays with extraordinary fluidity, whereas others develop it only to a moderate degree. As a class, English ball clays are highly fluid, the dark clays generally more so than the light. There are Tennessee clays which practically match the English clays in this respect.

It is to be noted in this connection that a fixed addition of casting salts to different ball clays is hardly likely to operate advantageously with all of them. Due to their varying soluble salt contents, ball clays respond quite differently to given amounts of casting salts.

Amount of Ball Clay Required

As a rule the average sanitary ware body for pressing does not contain sufficient ball clay to cast well. It is certainly true that the character

[1] Received Oct. 20, 1924.

and amount of the china clays used determine to a considerable degree the amount of ball clay needed, but only in exceptional cases can sanitary ware be cast with a ball clay content less than 14%. A reasonable maximum would be 20%. Also in many instances experience has proven the desirability of utilizing a blend of ball clays rather than a single clay. Likelihood of disturbance due to variations of quality of individual clays becomes correspondingly smaller, and by careful blending, smoother slip working properties can undoubtedly be attained.

Role of China Clays Whereas with ball clays the consideration of paramount importance is fluidity, with china clays this is of only secondary importance. It frequently happens that the results of viscosimeter tests of china clays which can be used interchangeably in casting bodies, differ most widely. From a casting standpoint the *sine qua non* with respect to china clays is proper behavior in a body *after* the molds have been filled.

Method of Test for Casting Behavior A very simple and useful test will illustrate. Tile casting molds measuring 3 x 6 x 1 inches with one-inch round plaster feeds in one end are required; also plaster funnels. Using the clay under test for the entire clay content, a 10-pound batch of test body is thoroughly mixed into a slip and dried on a plaster bat. To it is added a standard amount of salts (10 to 13 grams each of sodium carbonate and sodium silicate). The batch is then worked into a uniform casting slip of about twenty-nine ounces per pint depending somewhat on the clay, and poured into the molds, noting the time of filling. Using a blunt wire rod about $^3/_{16}$ inch in diameter, the funnel and feed hole are gently probed from time to time in order to determine within reasonable accuracy the time of feed shut-off. More than one tile should be cast, in order that final probing may be done in a mold which has not been previously disturbed. Also to be guarded against is nonuniformity of feed and mold condition. Results obtained in perfectly new molds can hardly be duplicated in a much older or in a wet mold.

Comparison of Clays Ball clays tested in this manner will register a clear open feed for as long as seven or eight hours. Some china clays on the other hand will close off in less than ten minutes, while others stretch out to an hour or slightly longer. To be observed also is the manner in which the tile has been formed, whether extremely hard and of accurate outline or whether the sides are hollowed and the center tending to be soft.

Some clays will scum the molds badly. Obviously, if a pure ball clay body remains open and soft-centered for a long time, one would naturally turn for correction to a clay permitting easy passage of water through the slip to the mold, one which shuts off quickly and packs solidly. Widely different clays accomplish this. Extremely gritty washed kaolins from

the south Appalachian deposits will serve this purpose. This type of clay is of a low plasticity and develops almost no flow whatever. As a result, it produces a sluggish slip. Other undesirable properties are very inferior green strength and poor vitrification. For the purpose however of "quickening" a casting body, of facilitating drainage from the middle of heavy sections, these clays operate to splendid advantage.

Certain off-grade English china clays meet the same requirements. Differing from the Appalachian clays, these clays become quite plastic and develop fair fluidity with additional advantages of much superior green strength and improved vitrification. Despite the wide variance of their ordinary physical properties, these two types of clays have in common the property of quick action in molds and solid casting. There is one slight difference to be noted. Where the American clay is used, the safe working range of the body in the mold is likely to be short. Slight delay on the caster's part in taking down his molds is likely to result in cracks. Using the English clay, the need for exactness in timing molds is not quite so imperative.

Between these two broad groups of slow open casting and quick solid casting clays, is a group of clays which because of their mid-way properties lend themselves well to the regulation of casting bodies. Assuming that a given body dries so rapidly in the molds that workmen cannot dismantle quickly enough to avoid cracks, the substitution of certain plastic Georgia kaolins in proper amount will tone down the speed of drying to a point of greater safety. The casting test shows that this clay retains an open feed for about an hour. It can accordingly be utilized to excellent advantage as a retarder in bodies where mold behavior is too rapid for safety. Another group of clays which belong in this general class are the Florida kaolins. The casting action of the better grades of these clays is slow. It is to be noted, however, that the natural drying shrinkage of some of these clays is so great that oftentimes any casting advantage is more than offset by losses from excessive shrinkage.

Casting Behavior

The mold behavior of a casting body should be such that the workman is not compelled to work at great haste to keep pace with it. Under ordinary circumstances molds should be left up $2^1/_2$ to 3 hours. As the percentage of non-plastic material in a body exceeds 58 to 60% the likelihood of preparing a safe easy-working body, gradually diminishes. With a clay content as low as 40%, one may not only expect weakness in drying and firing, but anticipate casting difficulties as well. In some instances, bodies are so designed that pieces may remain in their molds six or seven hours before dismantling without injury to the piece. Where much ware of intricate design is being made, a very slow body has decided advantages in that it allows a wide margin of time for each operation. For ordinary

ware, such practice is not strictly necessary, and may in fact invoke some hardship when unduly slow drying impedes production and compels the use of extra setters and extra floor space. Aside from the proper selection of clays, toughness in a casting body is generally a matter of *sufficient* clay content.

Use of Electrolytes It is of course well understood that manipulation of the salts used in preparing casting bodies offers a means of regulation. Soda ash and sodium silicate are the deflocculents in common use, and general practice is to use them together in equal amounts. Unfortunately owing to the different physical reactions of clays to these salts, generalizations on the extent to which a casting body can be controlled by this means are impossible. Some bodies require as low as twenty ounces each of soda ash and sodium silicate per 1000 pounds; others require double that amount. In a very general way, the greater the clay content the less the amount of salts required. Very frequently when a casting body sets up too rapidly, a reduction of casting salts will effect a remedy. What prevents broad statements in this direction is the well-known fact that a curve in which fluidity is plotted against gradually increased salts is not a straight line but a parabola.

Weight of Slip Very important in connection with the preparation of a casting body is the weight at which it is used. An added fraction of an ounce or less, oftentimes rectifies bad working properties. Again it becomes difficult to generalize, inasmuch as every body works best at its own peculiar weight. An average weight for ware of ordinary thickness would be $31\frac{1}{2}$ ounces per pint. The water content of such slip approximates 23%. Where the thickness of ware exceeds $\frac{5}{8}$ inch it will be found advantageous to use heavier slip, up to a weight of 33 ounces per pint. The usual accompaniments of excessive salts are scumming of molds, difficulty in delivering pieces from their molds, crusting of the piece in the mold and a tendency toward "salt blisters" on the edges of ware from the kilns. Where the amount of salts used is insufficient, the slip will be dead and sluggish and the tendency in the molds will be to remain soft and not pack.

Use of Grog The use of grog offers a valuable means of regulating casting bodies. For example in the manufacture of heavy sinks and urinals, where the immediate problems are not only to fill the piece solidly, but to avoid drying and firing loss from undue shrinkage, the addition of from 20% to 35% of 30-mesh vitreous grog, depending on the extent of the original clay content, will be distinctly beneficial.

In a coarse grog body it becomes necessary to increase the amount of salts normally used, particularly sodium silicate.

Ground to the fineness of commercial ground materials, vitreous grog

is an exceedingly useful ingredient in casting bodies. The extent to which it can be used depends again upon the clay content of the body in question. However, many bodies whose compositions do not readily lend themselves to casting, can be made to cast at most any desired rate of speed by the introduction of the proper amount of finely ground grog. The effect upon vitrification is very slight.

Correction of Slip Eliminating from discussion the very important considerations of mold design and mold condition, the suggestion is offered that initial effort to improve the casting qualities of a body begin with the weight of the slip. If pieces tend to crack in some particularly sensitive spot, both on the bench and from the kilns, perhaps a slightly heavier slip will slow up the casting process to a point of greater safety. As a second expedient, regulation of casting salts may bring about improvement. Where pieces remain in a soft unstable condition irrespective of a reasonable length of time in the mold, an increase in salts may be the answer. Where drying in molds is entirely too rapid and mold surfaces become badly scummed, improvement may follow reduction of salts. If neither nor both of these bring improvement, then undoubtedly there is need of toning the body composition one way or another as previously suggested.

Electric Porcelain & Mfg. Co.
Trenton, N. J.

A STUDY OF SLIPS FOR STANDARD FINISH TERRA COTTA (CONES 4-5)[1]

By H. E. Davis and J. S. Lathrop

ABSTRACT

The objects of the study were (1) to ascertain proportional limits of Cornwall stone, feldspar, flint and clays in terra cotta slips at cones 4–5, and (2) to evolve a slip that will be (*a*) highly vitreous, (*b*) white, (*c*) have a firing range which will not be affected by normal kiln variations and (*d*) freedom from crazing, checking, peeling and flaking. Compositions for various slips are given.

Objects

The objects of the present study are:

1. To ascertain proportional limits of Cornwall stone, feldspar, flint and clays in terra cotta slips at cones 4–5.

2. To evolve a slip that will be (*a*) vitreous to a high degree, (*b*) as white as possible, (*c*) sufficiently long firing range to be unaffected by normal kiln variation, (*d*) free from crazing, checking, peeling and flaking.

3. To note the effects arising from change of materials.

Work Reported by Others

Mr. Geijsbeek[2] notes that the use of flint is unsatisfactory, and, that a slip should have a shrinkage equal to or greater than the body to which it is applied, but never less.

R. T. Stull[3] brings out the following points of interest.

1. Cracking in the dry state is caused from too high a clay content, especially china clay. This is remedied by increasing non-plastic at the expense of clay, or by the addition of soluble material such as soda ash or borax.

2. Cracking in the fired slip may result from the same conditions, or from too high feldspar or Cornwall stone content.

3. Crazing is caused by too high content of flint, feldspar, or Cornwall stone; by firing a feldspar slip at too high a temperature, or a Cornwall stone slip at one too low.

In "Clay Glazes and Enamels,"[4] Henry Griffen mentions,

1. Flint tends to decrease shrinkage, stop cracking, and increase whiteness.

2. Cryolite at a given temperature produces a more vitreous slip than feldspar.

3. Ball clay tends to stop peeling, increase shrinkage and destroy whiteness.

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[1] Presented at the Summer Meeting, Los Angeles, Calif., Oct. 6, 1924.

[2] *Trans. Amer. Ceram. Soc.*, **4**, 48 (1902).

[3] *Trans. Amer. Ceram. Soc.*, **12**, 711–65 (1910).

[4] Chapters 6, 7, 8, 9, T. A. Randall, Publisher.

Present Investigation

Materials

The materials used were Cornwall stone and Swedish feldspar, imported from Harrison & Sons, England; a feldspar and flint obtained locally, English china clay, English ball clay, an especially plastic ball clay, known as English ivory fat clay and commercial whiting.

Method of Procedure

The work was divided into groups as follows:

1. A preliminary study to determine the safe limits of Cornwall stone, feldspar, clay and flint.

2. Two intermediate studies based upon the most satisfactory slip obtained in the preliminary work, to establish: (*a*) The use of whiting and flint over a closely confined range, (*b*) the finer limits of the use of Cornwall stone, feldspar and clay, and the proper proportions of china clay, ball clay and ivory fat clay.

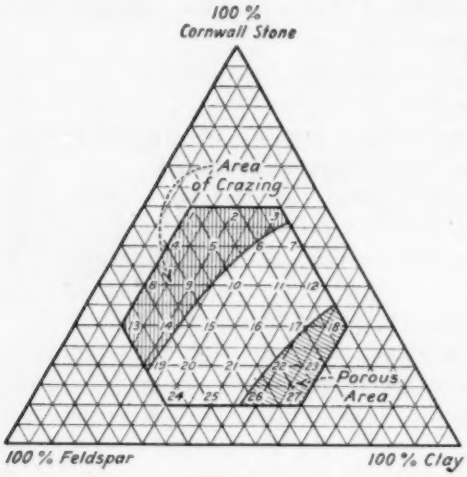

FIG. 1.

3. A study of the effect of soda ash and borax.

The preliminary study was laid out as shown in Fig. 1. Ten per cent increments were used throughout, making in all a series of twenty-seven members. Flint was introduced by direct substitution in 10% increments, making groups A, B, C and D, having 0, 10, 20 and 30% flint, with 100, 90, 80 and 70% of the base field, respectively. In each group, the six corner members, Nos. 1, 3, 13, 18, 24 and 27 were wet ground, and the intermediate members blended. The feldspar content was made up of one-half Swedish and one-half local feldspar, and the clay content half and half English ball and china clays.

Results in Preliminary Study

The results obtained from this part of the work are indicated on the accompanying figures 1 2, 3 and 4 and may be briefly summarized as follows:

Crazing

Crazing occurs in all group A members having less than 30% clay content, and extends to 40% clay where the Cornwall stone is highest. However, the crazing is more pronounced in the high feldspar area. The addition of flint in 10% incre-

ments pushes the crazing area farther and farther toward the maximum clay content, until in group D none is free except No. 27, having maximum clay and minimum Cornwall stone. Where no flint is included in the composition, crazing seems to go hand in hand with the overmatured, "greasy-looking," high feldspar slips, which is in accordance with Mr. Stull's remarks regarding overfiring slips high in feldspar. All slips low in clay and high in flux, either feldspar or stone, but more pronounced with feldspar, were apparently overmatured at cones 4–5.

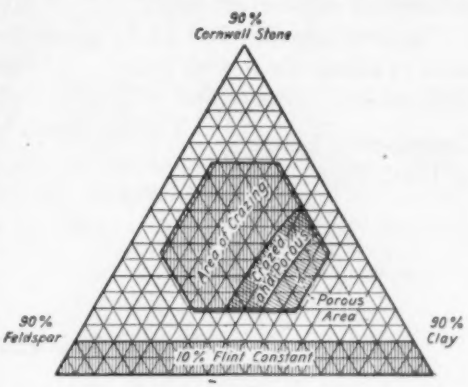

FIG. 2.

Crow's-footing

Crow's-footing, or checking of the slips was much more in evidence in group A, in the absence of flint, than in the other groups, all of which seemed about the same in this respect, indicating that 10% of flint is evidently a sufficiently non-plastic addition to overcome largely this difficulty. As would be expected, this defect was more pronounced with increase in clay, but worse with any given clay content with high feldspar than with high Cornwall stone, due, no doubt, to the presence of a large percentage of free flint in the Cornwall stone.

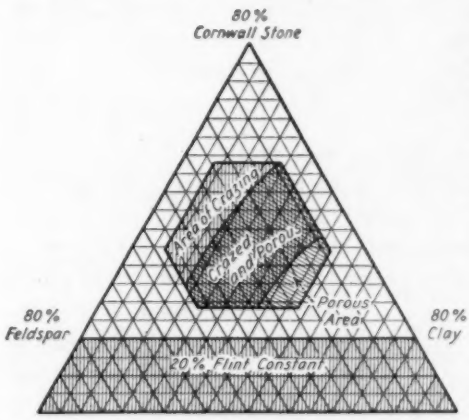

FIG. 3.

Color

None were a good white. A certain degree of translucency in the high feldspar of Cornwall stone slips produced a pinkish buff; while with increasing clay content, the ball clay developed a pale cream.

Hardness

Hardness or vitrification, was measured (also the crazing) by covering half the sample with writing ink, and washing off the unabsorbed. With no flint present, the vitreous, non-crazing area lay between the limits of 30% to 50% Cornwall stone, 10% to 30% feldspar and 30% to 50% clay. Below 30% clay and above 50% stone all slips are crazed. Above 30% clay and below 30%

stone, absorption was quite high. As little as 10% flint so increased the areas of crazing and immaturity that the two areas overlapped and left no area of satisfactory slips.

The best slip was No. 11 in group A (without flint). This slip was used as a basis for further study. Its composition is 40% Cornwall stone, 20% mixed feldspars and 40% mixed clays.

Composition Limits of Good Slips

The safe limits for vitreous, non-crazing slip are:

	Per cent
Cornwall stone	25 to 50
Feldspar	0 to 35
Clay	25 to 50
Flint	0 to 10 or less

Effect of Flint and Whiting

Number 11 group A was chosen as the base slip, having the following composition:

	Per cent
Cornwall stone	40
Local feldspar	10
Swedish feldspar	10
English ball clay	20
English china clay	20

Figure 5 shows the variation in whiting and flint.

Results

Whiting in any quantity up to 5% did not act as a flux, but rather as a refractory and a non-plastic, whitening the slip noticeably and apparently preventing crow's-footing. Flint up to 5% produced no crazing, and had no apparent effect other than to function as non-plastic and prevent crow's-footing the same as did the whiting.

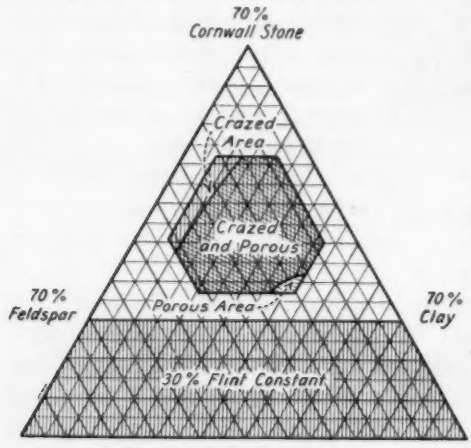

FIG. 4.

As flint up to this amount is apparently beneficial, it was decided to use 3% in a slip for subsequent investigation. Knowing from past experience that whiting shortens the safe firing range, but with the present evidence of improved whiteness and decreased crow's-footing a similar addition of 3% was decided upon, making the base slip formula:

	Per cent
Cornwall stone	37.6
Local feldspar	9.4
Swedish feldspar	9.4
English ball clay	18.8
English china clay	18.8
Whiting	3.0
Flint	3.0

With this slip as a basis the percentage amounts of Cornwall stone, feldspar and clay were varied but no satisfactory slips were developed. The cause for this apparently was the use of even so little as 3% of whiting, again indicating the range-shortening effect of whiting.

The effects of variations in Cornwall stone, feldspar and clay were slight.

The effects of variations in the kinds of clay were more pronounced than those caused by other variations. Increasing china clay increases refractoriness and whiteness. English ivory fat clay lowers the refractoriness to a slight degree, but insufficiently to warrant its use when not readily obtainable.

The softening effect of Swedish feldspar is negligible.

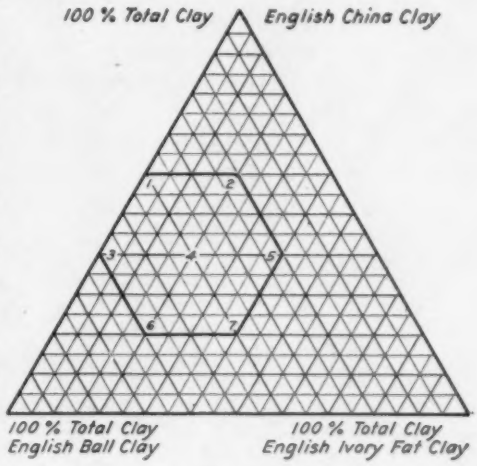

FIG. 5.

The slips containing neither flint nor whiting are all vitreous and free from crazing, being withal very good slips. The group containing 5% flint all show a strong tendency to craze.

No slips containing $2^1/_2$% of flint and whiting were vitreous.

A good slip can be obtained with only feldspar, Cornwall stone and clays.

Soda and Borax

Borax up to 1% apparently had no effect and the only effect of the soda was electrolytic, reducing the water necessary for proper fluidity by 20% to 40%.

General Conclusions

Results in a vitreous slip for standard finish terra cotta at cones 4–5 were:

1. A low clay content causes crazing.
2. Too high clay content decreases vitrification, and only between the limits of 30% to 50% clay can good vitreous slips be obtained.

3. Cornwall stone in quantities under 50% is beneficial. More than this amount produces crazing.

4. Good slips are obtainable with feldspar content up to 35% and perhaps higher.

5 Flint makes the slip more refractory and has a strong tendency to produce crazing.

6. Whiting even in very small amounts, decreases the firing range, and up to 5% acts as a refractory.

7. The addition of soda ash in the amount ordinarily used as an electrolytic has no apparent fluxing action.

No combination of materials was found which would produce a vitreous slip and at the same time a pure white one. No combination was found which would absolutely eliminate crow's-footing, but it is suggested that this might be overcome by different methods of spraying, or by the use of mica.

The proper proportioning of materials in the composition of a slip will, of course, vary considerably from place to place according to the different materials, the different body and different firing conditions, but the safe limits of composition of a satisfactory vitreous terra cotta slip at cones 4–5 will be as follows:

	Per cent
Cornwall stone	25 to 50
Feldspar	0 to 35
Clay	25 to 55
Flint	0 to 10 or less

TROPICO POTTERIES, INC.
GLENDALE, CALIF.

A GENERAL THEORY OF SPALLING

By F. H. Norton[1]

ABSTRACT

A theory is proposed whereby certain physical properties of a material are combined in such a way as to give a measure of its resistance to rapid temperature changes. The important physical properties are the coefficient of expansion, the flexibility in shear and the diffusivity. These quantities have been measured for a number of types of refractories and the theory checked by actual spalling results on these same refractories. The theory applies mainly to a single brick free from external stresses.

Introduction

Spalling is a term applied to the fracture or disintegration of a material caused by rapid changes in temperature. Here the term will be applied only to fire brick. A typical spalling fracture on an exposed corner shows a more or less spherical surface, indicating that the isothermal plane has been followed. In other cases where spalling occurs on the face of the wall, a thin layer of brick of rather even thickness is separated. At times a brick under service conditions will be cracked squarely across approximately in the center, but whether or not this should be considered a spall is in some doubt.

The ability of a brick to resist spalling is extremely important in the majority of places where refractories are used. It has been said by those having much practical experience that by far the greatest cause of failure in refractories is spalling. Therefore a brick is often selected for use because of non-spalling properties, even though the other characteristics are not altogether satisfactory.

While there have been a number of investigations carried out to study spalling, about all that can be concluded from our present knowledge is that a good non-spalling brick should have;

1. A low coefficient of expansion. 2. A coarse structure.

Perhaps much of our confusion on the subject of spalling is due to the laboratory spalling tests failing to give results in accordance with practice. To heat a brick in a laboratory test to 2400°F when it is to be used at 2900°F can obviously give no satisfactory results. Again it seems probable that quenching a brick in water will not give the same results as cooling it in a stream of air. A really satisfactory laboratory spalling test is greatly needed.

It was felt that it might be possible to determine the spalling qualities of a brick by measuring separately all of the properties that affect spalling and then properly combine them into a single term. To do this it is necessary to analyze carefully the mechanism of spalling.

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[1] Babcock & Wilcox Fellow, Massachusetts Institute of Technology. Recd. Nov. 28, 1924.

Temperature Distribution in a Homogeneous Solid

Let us first assume that we have a solid with one limitless plane face. Originally this solid is uniform at temperature Θ_1, but at time t_0 the surface is suddenly cooled (it does not matter in what manner) to a temperature of Θ_2. What is the temperature distribution in the solid for different values of t?

To solve this problem it will be necessary to apply Fourier's equations of the heat flow.[1] As the surface is infinite the isothermal planes will be everywhere parallel to the surface of the solid. Putting $\Theta_0 = \Theta_1 - \Theta_2$, or simply shifting the temperature scale, the temperature Θ at any distance below the surface X and at any time t will be given by:

$$\Theta = \frac{2\Theta_0}{\sqrt{\pi}} \int_0^{\frac{X}{2h\sqrt{t}}} e^{-B^2}\, dB \qquad (1)$$

where h is a constant of the material. h^2 is known as the diffusivity of a material or the rate at which a point in a hot body will cool under definite surface conditions and is equivalent to $\left(\frac{k}{c\rho}\right)$, where k is the conductivity, ρ the density and c the specific heat per unit mass.

It should be noted that equation (1) is in the form of the probability integral and can therefore be readily evaluated from tables.

As will be shown later, the stress set up in a homogeneous material due to a change in temperature is proportional to the temperature gradient at any point. It will therefore be necessary to differentiate (1) with respect to X. First writing (1) as a function of the limits:

$$\Theta = \frac{2\Theta_0}{\sqrt{\pi}} \left[\phi\left(\frac{X}{2h\sqrt{t}}\right) - \phi\,(0)\right]$$

then

$$\frac{d\Theta}{dx} = -\frac{2\Theta_0}{\sqrt{\pi}} \left[e^{\frac{-x^2}{4h^2t}} \cdot \frac{1}{2h\sqrt{t}} - 0\right]$$

$$= -\frac{\Theta_0}{h\sqrt{\pi t}} \cdot e^{\frac{-x^2}{4h^2t}} \qquad (2)$$

To show the practical application of this equation some curves have been plotted in Fig. 1 to give the temperature gradient ($h = .080$) when a body is cooled suddenly from 1500°F to room temperature. The gradient is of course highest at the surface but falls rapidly toward the interior. Near the surface the gradient falls rapidly with increasing time, but at

[1] Ingersoll and Zobel.

a certain depth, the gradient increases with the time. This is one of the reasons why spalling does not usually take place immediately after the specimen is chilled.

In an actual case the surface is not instantaneously cooled, first because a cooling medium cannot be instantaneously introduced, and secondly because perfect thermal contact cannot be made between the cooling medium and the surface of the brick. Equations (1) and (2) can be modified to take care of this effect as suggested by Ingersoll and Zobel, by adding a fictitious distance beyond the true surface. In this instance, however, as we are not interested in the region very close to the surface it will be more convenient to use a constant c to modify h.

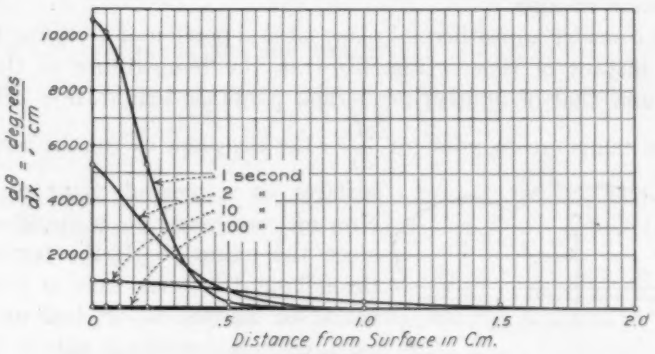


FIG. 1.

Only the case of an infinite plane surface has been considered. At the edge of a solid, the isothermal planes will not be parallel to the surface, but will be rounded off as in Fig. 2. This may be explained by considering that point A is cooled by the area abc in addition to the cooling received from an infinite surface such as a point at B. As the isothermals recede further from the surface the area abc increases and the corresponding departure from parallel conditions increases. The same conditions exist at a corner, except that the isothermal planes approach a spherical surface.

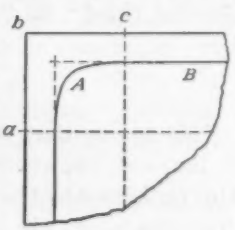


FIG. 2.

It is important to notice that the temperature gradient is slightly less at the edges and corners than on the faces of a cooling brick. Therefore the reason corners spall off is because of mechanical weakness rather than because of greater temperature gradients.

Temperature Stresses in a Homogeneous Elastic Solid

Spalling occurs almost universally along an isothermal plane. Therefore failure must be due to shearing, as it is inconceivable that any appre-

ciable tension could occur under these conditions, if there are no external forces.

The assumption must also be made that a brick is an elastic, homogeneous medium. It will be shown later that a brick is almost perfectly elastic up to the breaking point. The homogeneity will depend on the process of manufacture.

The exact evaluation of the stresses in a brick under a given temperature distribution cannot be solved mathematically except in a few simple cases. However it is here only required to find the tendency to spall in terms of the physical properties of the material. That is, comparative but quantitative results are desired between various types of brick tested in the same manner.

Let us consider an isothermal plane *ab* in a portion of a cooling brick at a given instant of time. (Fig. 3.) Let the temperature of the plane *ab* be Θ and that of another isothermal plane *dx* distant, $\Theta + d\Theta$, which gives the temperature gradient $\frac{d\Theta}{dx}$. Let the plane *cd* cut the isothermal surfaces at a neutral point of shear.[1] Now measure along *ab*, a distance *s*, and erect the plane *ef*. If the temperature throughout the brick were Θ this plane would be normal to *ab*, but under the existing conditions it will cut the $\Theta + d\Theta$ isothermal at a distance $s + s\Delta d\Theta$ from *cd*. Δ is the coefficient of expansion.

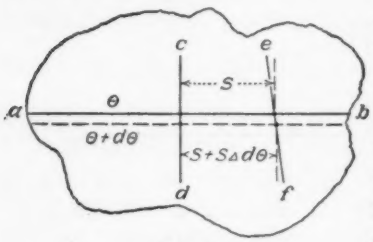


FIG. 3.

The shear strain is measured by the deflection of one plane in respect to another divided by the distance between them. In this case;

$$\phi = \frac{s\,\Delta\,d\Theta}{dx} = s\,\Delta\,\frac{d\Theta}{dx} \qquad (3)$$

This means that the strain set up in a cooling body is proportional to the size, the coefficient of expansion and the temperature gradient. This explains why thick glassware cracks on cooling or heating more readily than thin ware. In large pieces of refractory ware, the temperature distribution may be so uneven that strict proportionality to *s* may well be doubted. This does not greatly concern us, for we shall compare specimens of the same shape and size and with the same temperature gradient.

The shearing stress at any point is;

$$f = \phi\, n \qquad (4)$$

where n is the coefficient of rigidity.

[1] The neutral point will usually occur in a plane of symmetry in the brick.

From (2)
$$\frac{d\Theta}{dx} = \frac{c}{h} \quad [1] \tag{5}$$

where c is a constant.

Then the tendency to spall S is;

$$\frac{f}{f_1} = \frac{\phi n}{f_1} = \frac{S\Delta \dfrac{d\Theta}{dx} n}{f_1} = \frac{S\Delta \dfrac{c}{h} n}{f_1} \tag{6}$$

where f_1 is the shearing strength.

But for brittle materials,

$$n = \frac{f_1}{\phi_1} \tag{7}$$

where ϕ_1 is the maximum shearing strain.[2]

Therefore,

$$S = c \frac{s\,\Delta}{h\phi_1} \quad \text{or} \quad c_1\left(\frac{\Delta}{h\phi_1}\right) \quad S = \frac{\Delta}{h\phi} \tag{8}$$

This shows that the spalling tendency of a brick is proportional to the coefficient of expansion divided by the square root of the diffusivity and the maximum shearing strain.

Departure of a Brick from a Homogeneous Material

The expression just developed for the spalling tendency applies only to a homogeneous material; a brick, however, may depart from this to a considerable extent.

In the first place there may be cracks and laminations, which, if they are in a region of high stress markedly increase the spalling tendency. Such laminations undoubtedly cause the cases of unusually rapid destruction of a particular brick in a spalling test, but it is doubted that in general they have much effect.

When the grain size of a brick is large, it would be considered far from homogeneous, but even in extreme cases the grain is small compared with the pieces lost in spalling.

When a brick is heated in service or for a spalling test, the surface is much hotter than other regions; so that there is apt to be a variation in the physical characteristics from place to place. This is especially true when the brick has not been fired as high as the temperature of use. In

[1] $\dfrac{d\Theta}{dx}$ is proportional to $\dfrac{1}{h}$ as small changes of h in the term $e\dfrac{-x^2}{4h^2t}$ have little effect when t is reasonably large.

[2] The maximum shearing strain is the greatest distance a plane in the material can be moved parallel to another adjacent plane without rupture. The term flexibility might also be used.

extreme cases the hotter regions of the brick may be softened and vitrified.

If a brick is considered as an elastic homogeneous medium, it would be thought under given changes of temperature that either spalling would take place at the first temperature change or no spalling would occur with an infinite number of changes. What actually happens however is a gradual loss of material. This may be explained by the fact that small flakes are lost each time and thus present new surfaces. Again cracks are started and gradually extend until they go across from surface to surface.

In order to determine how much the above causes of unevenness in the brick affect the agreement between the theoretical and actual spalling results, a number of brick have been carefully tested for physical properties and spalling.

The Maximum Shearing Strain, Stress and Coefficient of Rigidity of a Number of Fire Brick

In order to measure the characteristics of the brick as listed below, a number of 1 x 1 x 9 inch square bars were sawed out of each specimen. These bars were then cemented into holders and the angle and torque measured up to the breaking point. It would have been interesting to have had this test carried out to high temperatures, but the cost and difficulties would have been great, so a temperature of 500°C was used in each case.

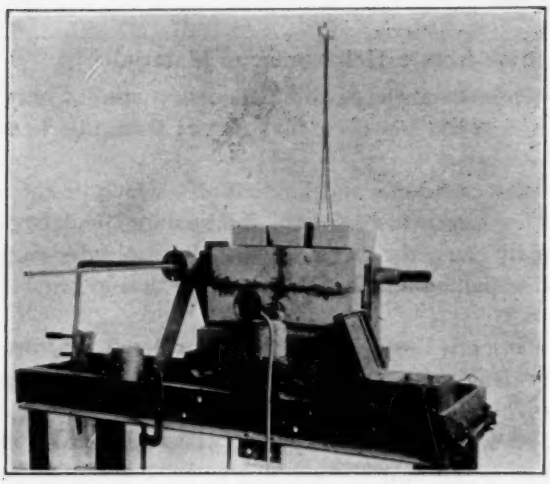


FIG. 4.

Such a low temperature is justified because it has been noticed that in nearly every case spalling occurs at about red heat.

In all cases where the specimen was carefully held, there was no permanent set after removing the torque until a point was reached just before failure. That is the specimens all acted as if perfectly elastic.

The apparatus used for these tests is shown in Fig. 4. A precision of about 2% was attained in all cases.

The brick tested are described in Table I below and represent a wide range. Some are experimental brick and others are extensively used.

TABLE I

Brand	Material	Grog	Bond	Hardness	Approximate burn. temp., °F	Remarks
A	Fire clay	Very coarse	Soft	Soft	2300	Commercial brick
B	Sillimanite	Medium	Little	Hard	3050	Special brick
C	Fire clay	Very coarse	Soft	Medium	2600	Same as *A* hard burn
D	Si C	20-mesh	Molasses	Hard	2800	Special brick
E	Fire clay	Coarse	Soft	Soft	2400	Commercial brick
F	Bauxite	Fine	Little	Hard	3100	Special brick
G	Fire clay	Medium	Soft	Soft	2400	Commercial brick
H	Kaolin	Medium	Little, hard	Very hard	3000	Commercial brick
I	Fire clay	Fine	Soft	Soft	2300	Commercial brick
J	Fire clay	Medium	Hard	Hard	2300	Commercial brick
K	Fire clay	Fine	Soft	Soft	2300	Commercial brick
L	Spinel	Medium	Hard	Hard	2500	Commercial brick
M	Silica	Fine	None	Hard	2700	Commercial brick
N	Same as *C* preheated to 2900					

The properties of the brick given in the table below are relative. The shearing strain is the angle through which the opposite faces of a one-inch cube are twisted. The shearing stress is the torque required to twist to this angle. The coefficient of rigidity is the ratio of the two.

TABLE II

Brand	Max. shear strain = ϕ	Max. shear stress, gm. cm.	Coefficient of rigidity
A	.114	45,000	400,000
B	.052	125,000	2,400,000
C	.050	44,000	880,000
D	.072	360,000	5,000,000
E	.057	63,000	1,100,000
F	.032	465,000	14,500,000
G	.090	37,000	410,000
H	.050	165,000	3,300,000
I	.107	64,000	1,070,000
J	.050	83,000	1,660,000
K	.089	70,000	790,000
L	.032	60,000	1,980,000
M	.094	160,000	1,700,000
N	.060	120,000	2,000,000

Each value is the average of a number of tests. Tests at 500°C.

The maximum shear strain varies between .032 and .114 or nearly four to one. The stress varies between 37,000 and 465,000, a ratio of 12. The rigidity varies between 400,000 and 14,500,000, a ratio of 36 as the strongest brick have the least deflection as a rule.

It will be noted that brick *N* which is the same as *C*, but preheated to a high temperature, shows a slightly increased flexibility and a greatly increased strength.

The Coefficient of Expansion of a Number of Fire Brick

A 1 x 1 x 9 inch specimen of each brick was placed in an electrically heated tube furnace and the expansion measured with micrometer telescopes. The coefficient in most cases was constant with change of temperature but the values given in Table III are for 500°C.

TABLE III

Brand	Coefficient of expansion (C) =	Brand	Coefficient of expansion (C) =
A	.0000051	*H*	.0000063
B	.0000039	*I*	.0000133
C	.0000050	*J*	.0000071
D	.0000031	*K*	.0000126
E	.0000053	*L*	.0000116
F	.0000037	*M*	.0000405
G	.0000104	*N*	.0000072

In general the brick highest in Al_2O_3 have the lowest coefficient of expansion, and those highest in SiO_2 the greatest. As an analysis of the brick is not available it is not possible to state whether there is a definite relation between the expansion coefficient and the composition. It is interesting to notice, however, that brick *N* which is the same as *C*, except preheated to a high temperature, shows a material increase in the coefficient of expansion. It is probable that brick heated high enough to combine all free silica will show a low coefficient of expansion.

The variation in coefficient of expansion between different fire brick is considerable and may account for discrepancies sometimes noted in wall expansions.

The Relative Diffusivity of a Number of Fire Brick

The value of the diffusivity can of course be obtained by measurements of thermal conductivity and specific heat. These measurements however take some length of time, so a method of measuring the relative diffusivity was devised.

A two-inch cube of the material was cemented up from four 1 x 1 x 2-inch blocks with a thermal junction at the center. This cube was suspended by the junction wires in an electric furnace until it had reached an even temperature of about 550°C; then it was taken out and suspended in a room free from drafts. The temperature of the center was recorded, and the slope of the cooling curve at 500°C was taken as the value for the diffusivity. This method is rapid and accurate where only relative values are desired.

The values for the specimens tested are given in Table IV below. The units are entirely arbitrary and the results are only comparative among themselves.

TABLE IV

Brand	Diffusivity = h^2	h	Brand	Diffusivity = h^2	h
A	38.2	6.2	*H*	40.4	6.4
B	42.6	6.5	*I*	39.2	6.3
C	39.6	6.3	*J*	36.6	6.0
D	67.2	8.2	*K*	37.8	6.2
E	42.3	6.5	*L*	41.1	6.4
F	38.7	6.2	*M*	44.4	6.7
G	38.9	6.2	*N*	36.8	6.1

Tests at 500°C

With the exception of the Si C specimen the value of h varies only a few per cent and is not usually an important factor in spalling.

Comparison between the Spalling Formula and Actual Tests

The results from laboratory spalling tests are available for the various specimens tested, and it was thought that a comparison between these results and the spalling formula would be interesting. This spalling test is somewhat different from the A.S.T.M. test in that the brick are heated each time to 2900°F and are cooled in a stream of air. A very careful comparison between this test and actual service has been made, and the agreement was found to be excellent. From five to ten brick of each kind were spalled and the average is given here.

Attention should be called to the two values given for brick *B* and *F*. These two brick both showed the regular type of spalling at the lower corners for several quenches, then suddenly the brick broke sharply across

TABLE V

Brand	ϕ		h	$(\Delta/\phi h)$	No. of quenches
A	.114	.0000051	6.2	72×10^{-7}	26.5
B	.052	.0000039	6.5	115	8.0
B	.052	.0000039	6.5	115	24.0
C	.050	.0000050	6.3	157	23.0
D	.072	.0000031	9.9	44	..[1]
E	.057	.0000053	6.5	143	15.6
F	.032	.0000037	6.2	110	2.0
F	.032	.0000037	7.3	159	15.0
G	.090	.0000104	6.2	187	12.2
H	.050	.0000063	6.4	197	10.6
I	.107	.0000133	6.3	197	8.4
J	.050	.0000071	6.0	237	5.2
K	.089	.0000126	6.2	229	2.7
L	.032	.0000116	6.4	567	2.4
M	.094	.0000405	6.7	644	.3
N	.060	.0000072	6.1	197	..

[1] No exactly comparable spalling value was available for this brick but it is undoubtedly lower than should be expected as an oxidizing atmosphere tends to convert the SiC into SiO_2 and thereby raise the coefficient of expansion.

near the center. The first value then gives the number of quenches until this break occurs and the second, the number, estimated from the amount lost at the tip, that it would have gone had the brick not broken in the center. This peculiar behavior needs further study.

If the value of $\frac{\Delta}{h\phi}$ is an index of the spalling tendency of a brick, as indicated by the theory, then these values plotted against the number of quenches for each specimen should fall along a curve rather than be widely scattered. Such a plot has been made in Fig. 5 and it is quite clear that the points group themselves into a definite band. The deviations that do occur can be explained by the fact that some of the brick were altered in heating from their original characteristics.

Specimen K which is considerably below the mean curve was noticeably laminated in structure. The higher values for brick B and F were only estimates.

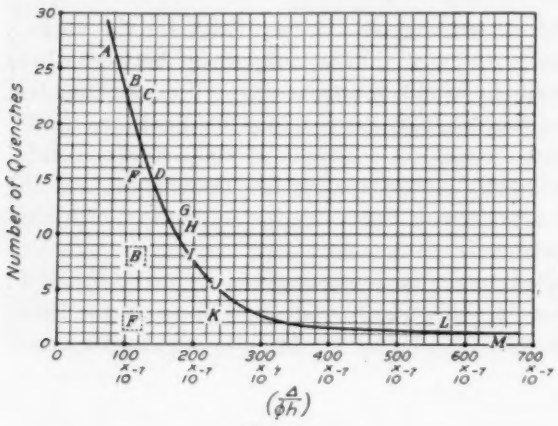


FIG. 5.

The form of the curve is of interest for it approaches a rectangular hyperbola asymptotic to the two zero axes. When the value of $\frac{\Delta}{\phi h}$ is high the brick show little difference in spalling resistance as they are almost completely shattered at the first temperature change. On the other hand the brick having a low value of $\frac{\Delta}{\phi h}$ increase rapidly in spalling resistance as $\frac{\Delta}{\phi h}$ is decreased. This behavior is not unexpected as it is simply an approach to a classification of brick into two sets, those that spall on the first quench and those that do not spall under an infinite number of quenches, as was previously discussed.

The best spalling brick of those tested withstood 26 quenches and had a value of $\frac{\Delta}{\phi h}$ of 72×10^{-7}. Suppose that by slightly increasing the flexibility or decreasing the coefficient of expansion a value of 50×10^{-7} were obtained, the brick should then withstand about 50 quenches. This illustrates the possibilities of making remarkable non-spalling brick.

On the whole it would seem that the theoretical work agrees with prac-

tice as closely as the nature of the tests will allow. While this new method cannot be recommended to replace the usual spalling tests without a more thorough trial, it is felt that more information is obtained as to the causes of spalling in a certain brick than by other methods.

Characteristics of a Good Spalling Brick

It is probably impossible to greatly vary the diffusivity of a brick and not destroy more important characteristics. The coefficient of expansion is dependent to a large extent on the material which oftentimes is fixed, but it seems probable that some change can be made by heat treatment and combination of free silica.

The flexibility of a brick, however, can be varied to a large extent by the manufacturer and it is here that efforts should be directed. A small increase in flexibility greatly increases the resistance to spalling. In general the most flexible brick are composed of rather large, hard grog particles held together with a soft porous bond. It is significant that the best non-spalling brick of the lot tested also had the greatest flexibility.

Conclusions

A theory of spalling has been developed which combines certain easily measured physical properties of a material to give a figure of merit which has been shown to agree well with actual spalling tests.

It is shown that a good spall-resisting brick should have (1) a high diffusivity, (2) a low coefficient of expansion, and (3) a high flexibility in shear.

This theory allows the study and development of spall-resisting brick on a scientific basis, but as yet only a beginning has been made on finding out how to vary the physical properties of the brick in the desired way.

In carrying this work on it would be interesting and valuable to determine:

1. The temperature distribution in a cooling brick by means of thermocouples fired into the clay and check these results with the theory.
2. The values of h, ϕ and Δ at all temperatures in order to find where $\frac{\Delta}{\phi h}$ is a maximum.
3 The effect of SiO_2 and Al_2O_3 content of a brick on the coefficient of expansion; also the effect of various firing temperatures and structures.
4. The effect of structure and firing temperature on the flexibility.

Acknowledgment

A large part of the experimental work carried out for this paper was done by Robert Richardson, at Massachusetts Institute of Technology.

THE CHANGES WHICH TAKE PLACE IN SILICA BRICK DURING THEIR USE IN OPEN-HEARTH FURNACES[1]

By W. J. Rees

ABSTRACT

A test on silica brick during their use in open-hearth furnaces is described. Four zones of varying characteristics in a silica brick are noted. A table presents the changes in composition and refractoriness which take place in brick used in basic and acid open-hearth furnaces. With highly converted brick, durability may be promoted indirectly by greater structural stability of the roof.

In the symposium on the "Selection of Refractories for the Open Hearth" conducted by D. A. Lyon,[2] reference was made by several speakers to the changes which take place in the structure of silica brick during their use. It was stated that when a roof brick which has glazed over, spalls, the freshly exposed surface fuses and drips. In this connection the following analysis and refractory test is of interest.

The appearance and structure of a silica brick which has been in use in an acid open-hearth furnace is shown in Fig. 1. At least four distinct zones may be distinguished: *A*, the end of the brick which has been exposed to the furnace. This zone is gray in color and the material has been more or less completely fused and it is by the flow of this layer that corrosion mainly takes place. It consists chiefly of cristobalite and magnetite. *B* is a black zone graduating into brown on its cooler end. Some traces of the original structure of the brick are visible, but the zone consists mainly of crystals of tridymite in a matrix of magnetite.

The contraction of zone *A* has caused the expulsion of the ferruginous slag into zone *B*. The silicates and alumina silicates of lime and alkalis, which have a lower viscosity, are carried in advance of this slag into zone *C* when a concentration of lime and alumina is found. This zone is usually brown in color, paling toward the cooler end. The increase in fuses reduces the refractories of this portion of the brick so that if, through defective management of the furnace, the brick becomes overheated fusion may occur. Rapid destruction of the brick may be caused by overheating it (such as by direct contact with a kiln flame) before it has become "seasoned" by impregnation with magnetite and the expulsion of the lime.

[1] Received November, 1924.

[2] *Jour. Amer. Ceram. Soc.*, **7** [9], 705 (1924).

Note: (*a*) Complete penetration of hot end of brick by iron oxide. × 100.

(*b*) Skeletal crystals of cristobalite in glassy matrix. × 200.

(*c*) Large proportion of the quartz converted to twinned tridymite. × 50.

(*d*) Tridymite crystals, with residual quartz fragments surrounded by cristobalite. × 25.

(*e*) Fragments of unconverted quartz with cristobalite and tridymite in the matrix. × 25.

(*f*) This portion of the brick is practically unchanged. The fragments of ganister have unaltered cores. Tridymite and some cristobalite in matrix. × 25.

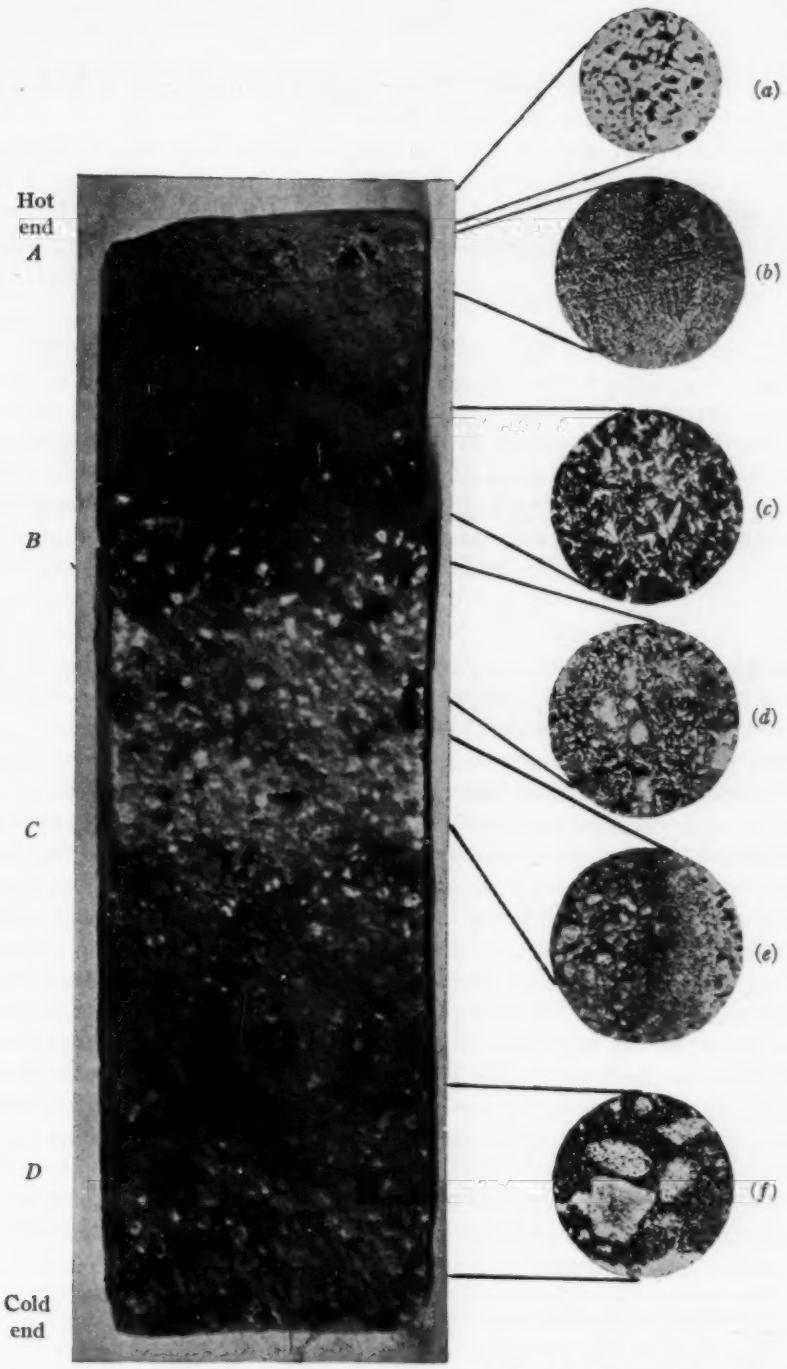


FIG. 1.—Vertical section and photomicrographs of silica brick from roof of open-hearth furnace. (See Note, page 40, for further description.)

Zone *D* is unchanged brick. Under normal circumstances it does not become hot enough for changes to occur.

The exact extent of these zones is a function of the temperature gradient through the brick. Changes of a similar character may be observed in brick which have been in use in a basic open-hearth furnace. The following table shows the changes in composition and refractoriness which take place.

BRICK FROM ROOF OF ACID OPEN-HEARTH FURNACE[1]

Zone	Structure	SiO_2	Fe_2O_3	FeO	Al_2O_3	CaO	MgO	Mn_3O_4	Refractoriness Cone
A	Cristobalite	79.6	13.6	5.7	0.8	0.1	.....	0.3	33
B	Tridymite	74.8	19.0	4.4	1.1	.3	....	.2	33
C	Transition	91.0	2.5	...	2.7	3.4	0.05	.2	28
D	Unaltered	95.4	1.3	...	1.0	1.8	....	.1	32

BRICK FROM ROOF OF BASIC OPEN-HEARTH FURNACE[1]

Zone	Structure	SiO_2	Fe_2O_3	FeO	Al_2O_3	CaO	MgO	Mn_3O_4	Refractoriness Cone
A	Cristobalite	88.5	5.2	1.3	0.6	2.7	0.4	1.1	30
B	Tridymite	87.2	6.8	0.9	.8	2.8	.4	1.0	31
C	Transition	88.6	3.0	...	2.9	4.8	.3	0.3	27
D	Unaltered	96.2	0.9	...	1.1	1.5	.1	.1	32

It is apparent from these analyses and refractory tests that if the portion of the brick represented by zones *A* and *B* spalls away, the freshly exposed portion represented by zone *C* will quickly fuse and drip.

Two properties of silica which favorably affect the behavior of silica refractories in high temperature furnaces are (*a*) melts derived from silica have a high viscosity and there is consequently a definite tendency for the formation of a protective fluid or semifluid layer. (*b*) The flatness of the melting point curve of silica is such that at high temperatures, even in the presence of a good deal of impurity, much of the silica remains solid.

There has been from time to time a good deal of discussion as to the advantage or otherwise of high quartz conversion in promoting the durability of silica brick in the open-hearth furnaces. H. H. Thomas[2] has suggested that the actual density-concentration of silica is of more importance than the crystalline form in which it is present. There is something to be said in support of this view, but my own experience is that both high quartz conversion and high silica concentration are desirable if maximum durability is to be obtained. With highly converted brick durability may also be promoted indirectly by the greater structural stability of the roof as alterations in contour from excessive after-expansion may adversely affect the economies of the furnace.

DEPARTMENT OF REFRACTORY MATERIALS
UNIVERSITY OF SHEFFIELD, ENGLAND

[1] (See also J. E. Stead, *Trans. Ceram. Soc.* (Eng.), **18,** Pt. 2; C. S. Graham, *Trans. Ceram. Soc.* (Eng.), **18,** Pt. 2.

[2] *Geol. Survey,* Spec. Reports, **16.**

ADAPTATION OF TUNNEL AND CAR KILNS TO FIRING REFRACTORIES[1]

By Philip Dressler

ABSTRACT

The success of tunnel kilns in a given industry is largely determined by the choice of the type best suited to the requirements of that industry. This paper discusses the adaptation of the various types of tunnel kilns to firing glass house refractories, clay, fire brick and silica brick.

Introduction

The report of the Committee of the Refractories Manufacturers Association on tunnel kilns[2] cleared up points of doubt regarding the success of tunnel kilns for firing refractories. There are tunnel kilns in this country firing satisfactorily and uninterruptedly at the highest temperatures required by the industry and on materials offering in many respects more serious firing difficulties than the great majority of refractory products. There are kilns firing tonnages of clay products of the same sort as refractories.

Tunnel kilns have demonstrated (*a*) a fuel saving of from 50 to 70% over intermittent kiln firing practice; (*b*) a saving of labor due to the better working conditions and the localization of the setting and drawing operations; (*c*) an increase in proportion of No. 1 grade ware due to better control at all stages of the fire and the ability to fire to higher temperatures without kiln marking on account of uniformity of burn and the low setting height of the ware; (*d*) shortening of the time required for firing, leading to a marked reduction in the quantity of material in process of manufacture and to the ability to fill orders for special material rapidly.

As pointed out by the Committee, there are a large number of tunnel kilns in Europe firing refractories. The reason they have not been employed more largely in America is that tunnel kiln designers have not sufficiently appreciated the variety of problems presented by the different kinds of refractories and have attempted to apply without modification kilns which have proved satisfactory in other lines, and under different conditions, to the refractory field. To be successful tunnel kilns must be designed and adapted to meet the conditions offered by the different divisions of this industry.

The Problems Peculiar to Firing Refractories

Generally speaking, from the standpoint of the tunnel kiln designers the refractories industry can be divided into three main sections:

[1] Presented at the Atlantic City Meeting, Feb., 1924 (Refractories Division). Recd. Oct. 1, 1924.

[2] Preliminary report of the Committee on Fuel Conservation on the Railroad Tunnel Kiln, *Jour. Amer. Ceram. Soc.*, **5** [9], 602 (1922); A. F. Greaves-Walker and S. M. Kier, "The Suitability of the Tunnel Kiln for Burning Refractories," *Jour. Amer. Ceram. Soc.*, **6** [8], 891 (1923).

(1) Heavy and large special fire clay refractory shapes such as are used chiefly in the glass industry.

(2) Ordinary fire clay fire brick firing at temperatures not to exceed cones 14 to 16 and usually considerably lower, capable of being fired on a relatively short cycle and presenting no great firing problems.

(3) High fire refractories requiring temperatures of cone 18 and up and necessitating long periods of heat treatment to bring about complex mineralogical changes both in the firing and in the cooling, for instance silica, magnesite, chrome and other special materials.

Heavy Shapes

On account of the difficulty of manufacture, length of time required for drying, high cost and other such factors, the usual plant manufacturing glass house refractories does not produce a tonnage to exceed thirty tons per day. This field, therefore, offers no great tonnage problem to the tunnel kiln designer. What is required to produce perfect results is an exceedingly steady, slow and controlled heating combined with a period of uniform temperature sufficiently long to give complete penetration to the center of individual pieces which in some cases may weigh as much as 2500 to 3500 pounds each. It is apparent that any rapid change of temperature at any point whether in the heating or cooling is bound to affect the outside of such pieces without affecting the inside and, therefore, to set up heavy strains. A sudden flash of heat in the high temperature region where vitrification is starting is quite sufficient to cause shrinkage and cracking of the outside layers over the inner core.

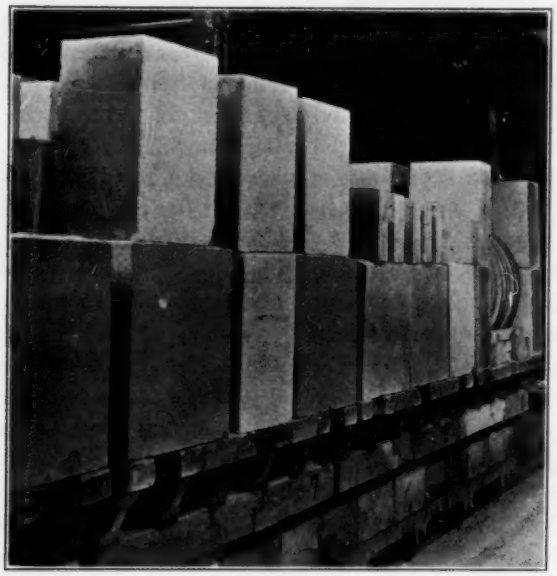


FIG. 1.

The kiln to meet the required conditions must provide the most gentle heating and cooling and the easiest control in all stages. In the opinion of the writer the muffle type of kiln is the one which most successfully can meet these requirements.

Muffle tunnel kilns are in use in this country for the firing of glass

house refractories. The Committee has described the one at the Ohio Valley Clay Company. It has now been in operation for six years. Figure 1 shows the kind of ware fired in this kiln. Several others have been installed by the glass industry for preheating the heavy pots which in some cases are as much as four feet six inches wide, by six feet long, by forty-five inches high, weighing 3850 pounds and having thicknesses up to ten inches. These units have all been highly satisfactory and it does not appear that any other firing method can equal the results obtained. Figure 2 illustrates the entrance end of a pot arching kiln and Fig. 3 a pot being withdrawn at the hot end at 1800°F.

Fire Clay Brick

The direct fire kiln with longitudinal draft, in which the gases of combustion are drawn from the fire boxes, at about the center of the kiln, toward the offtake ports at the entrance of the kiln, is best adapted to firing this class of ware both on

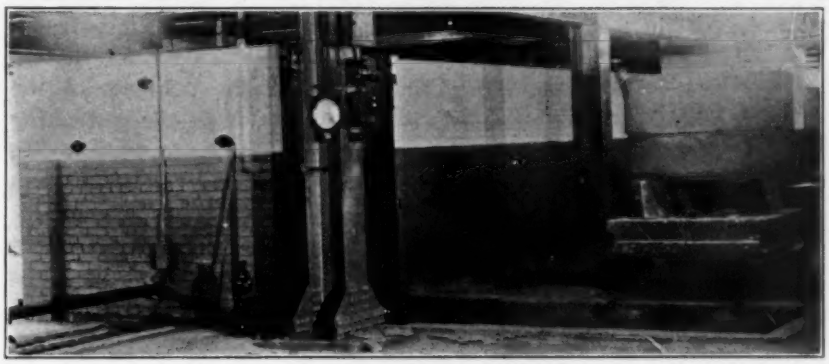


FIG. 2.

account of cheapness of installation and simplicity of design. The chief problem in the past has been to provide a kiln which will handle sufficient tonnage. It is possible to design a kiln to produce up to 25,000 or 30,000 nine-inch equivalents or approximately 100 tons per 24 hours. To fire on a 72-hour cycle, such a kiln needs to be about 350 feet long. The earlier difficulties experienced by the designers in obtaining an even heat distribution in the high heat zones of this type of kiln, have been largely overcome by the more refined methods of burning the fuel and introducing the products of combustion into the kiln chamber. The practical size for the kiln car is one which carries six headers in the width and is loaded fifteen courses high giving about 1500 brick per car six feet long. The method of loading is shown in Fig. 4.

Kilns of this type have been built in this country from time to time, some of which have been more successful than others and some have been failures. Difficulties of operation experienced have been largely due to an

inherent problem in this type of kiln to secure a good distribution of gases through the ware in the earlier stages of heating. The natural tendency of the gases is to pass through the space between the top of the ware and the crown of the kiln. When the gases reach the vicinity of the draft points they flow practically entirely in the space between the ware and the walls. This space cannot be avoided. There must be ample clearance everywhere to prevent a loose brick or poor setting from causing a wreck and these spaces are as a rule increased by the natural shrinkage of the material.

Fire clay goods offer a problem not presented by saggered ware in which the space occupied by the ware is constant throughout the length of the kiln. The result of the tendency of the gases to pass between the load and the kiln walls is that the center bottoms are not heated up satisfactorily in the early stages. As a rule such a kiln presents two very different heat curves for the top and the center bottom of the car. The top of the car follows approximately the heat curve of the crown of the kiln. The bottom lags far behind until when it comes opposite the first fire boxes its temperature is suddenly and rapidly raised. Due to the coldness of the bottom center brick in the preheating zone of the kiln there is a tendency to condense water vapor upon themselves which in some cases, especially of dry press brick, has led to serious slumping problems. These same brick, when they reach the first fire boxes then tend to have their temperatures raised so rapidly that they are cracked.

FIG. 3.

Many expedients have been adopted by tunnel kiln users to combat this. To close the space above the top of the ware as close as possible some have added baffles hanging from the arch, others have used baffles set upon the top of the ware to conform to the shape of the arch. The kilns designed by M. Faugeron, the parent type of today's direct fire kiln, were provided with recesses in the side walls with narrow points opposite each other on the two sides of the kiln, the object being to cause the gases to wind in and out of the recesses and give them a direction towards the center of the car. In other designs these recesses have been staggered with respect to each other, the idea being to cause the gases to follow a serpentine path through the preheating section of the kiln. It does not appear, however, that any of these recesses can prove very effective in accomplishing their object. Space must be left between the cars, the roof and the side walls. Gases in motion have momentum and under the influence of the suction at the entrance end of the kiln, a purely negative influence such as is produced by the devices mentioned above will not cause them to be de-

flected to any appreciable extent from the most direct path from the center to the entrance end of the kiln. Their mass and their momentum are too great. To change the direction of the gas stream a positive force is required.

In a recent installation of a direct fire tunnel kiln of the longitudinal draft type such a force has been applied so as to cause an even heating of the ware in the preheating zone by a positive circulation of gases through the lower part of the cars. This has been achieved by the application of the principle of draft reversal. The offtake flues on the two sides of the kiln are connected independently to the source of draft whether fan or stack. The draft is applied alternately to these flues so that for one interval all the draft is on the right hand side and for another interval is on the left hand side. (See Fig. 5.) In the construction of the kiln provision is made to prevent gases from passing from one side to the other over the top of the ware. (See Fig. 6.) At each reversal then in finding their way from the space between the ware and kiln, down which they normally travel, to the draft ports, on the opposite side, half the gases are obliged to pass through the ware from one side to the other. There are, of course, an infinite number of ways of bringing about this draft reversal. In this particular case, as illustrated in the accompanying photograph (Fig. 7) the reversing gear is driven directly from the coupling on the fan drive through a system of belts and reducing gears and is so arranged that the full draft is on each side for eight minutes and two minutes is consumed in changing from one side to the other. It is felt that this device offers a very simple solution of what has heretofore been a baffling problem in the design of this type of kiln.

FIG. 4.

High Fire Refractories, Silica Brick and Allied Products

Apart from the high maturing temperature and the danger of cracking at all stages the main problem to be solved in firing silica brick and applied products in tunnel kilns is to obtain sufficient production from a kiln of reasonable length. J. Spotts McDowell has stated to the writer that in his opinion a firing cycle of 120 hours is the shortest one on which silica brick of American

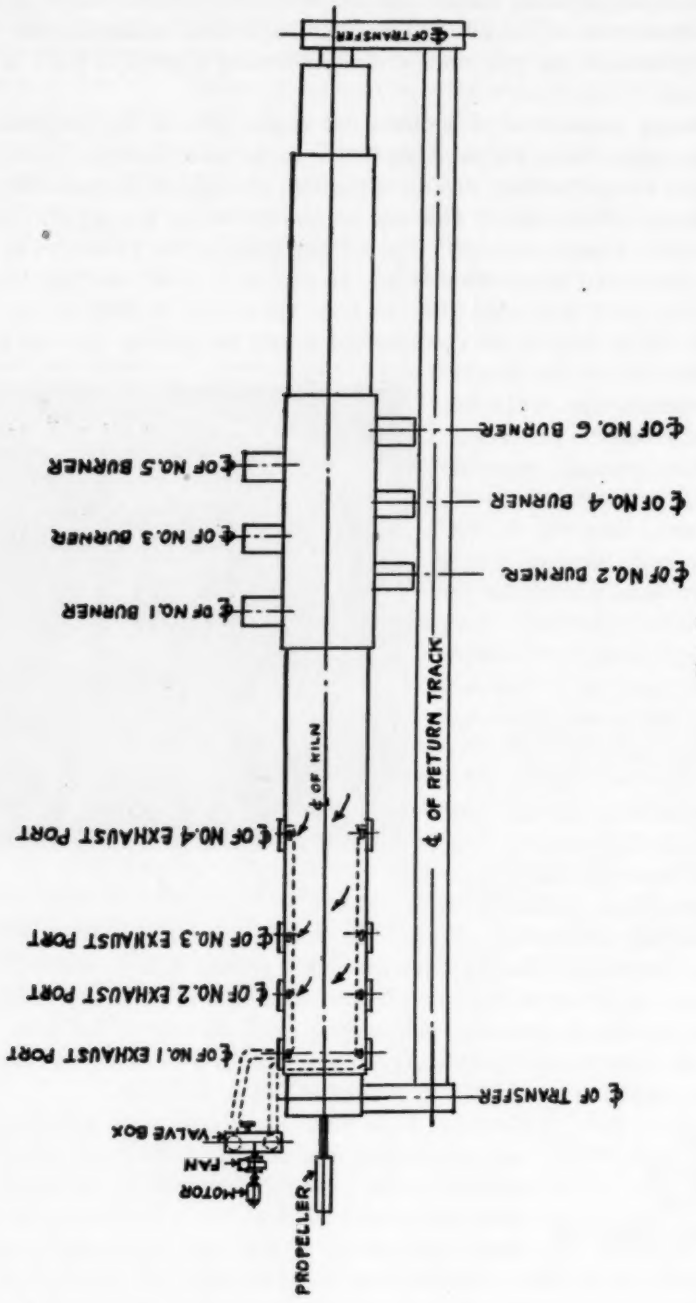

℄ OF TRANSFER
℄ OF NO. 6 BURNER
℄ OF NO. 5 BURNER
℄ OF NO. 4 BURNER
℄ OF NO. 3 BURNER
℄ OF NO. 2 BURNER
℄ OF NO. 1 BURNER
℄ OF RETURN TRACK
℄ OF KILN
℄ OF NO. 4 EXHAUST PORT
℄ OF NO. 3 EXHAUST PORT
℄ OF NO. 2 EXHAUST PORT
℄ OF NO. 1 EXHAUST PORT
℄ OF TRANSFER
VALVE BOX
FAN
MOTOR
PROPELLER

FIG. 5.

manufacture can be properly burned and on this cycle to obtain complete inversion a temperature of 1475°C must be maintained for eighteen (18) hours.

The longitudinal draft direct fire kiln described in the preceding section is very distinctly limited in width due to the difficulty in obtaining even conditions from side to center, not only in the firing zone but in the heating up and cooling off sections. Silica brick are very sensitive to cracking in these periods and unless a very even temperature condition can be maintained over the full cross-section at all stages, the firing cycle must be still further lengthened in order to insure that the material in the worst position receives the proper treatment, thus making the problem of adapting the tunnel still greater.

FIG. 6.

Since a car carrying six headers in the width is about the limit of what is practical in this type of kiln and assuming the minimum cycle of 120 hours, a very long kiln would be required to fire a satisfying tonnage of silica brick. In the report of the Refractories Committee, lengths of from five hundred to seven hundred feet for this type of kiln are mentioned. Such lengths do not appear to be practical. Few plants have sufficient space available for them and the distance through which the cars have to be moved both in the kiln and on the return tracks appear too considerable for practical, economical operation. What is required is a kiln which will permit of a much greater cross-section and which will hold many more brick to the foot run and yet permit an even heat distribution and the necessary control of the heating and cooling curves. In the opinion of the writer this can be achieved by the use of the Cross Fire Regenerative Kiln mentioned in the report of the Refractories Committee. Since no account of this kiln has appeared in the available literature, it may be of interest to describe it here.

In this type of kiln, the gases, instead of being drawn longitudinally from the center toward the entrance end, pass transversely across from side to side. Two advantages arise from this—(*a*) the heating medium

only traverses one zone and it is, therefore, possible to regulate each section of "heating up" and "furnace zone" independently of every other one. This manifestly is not possible where all the gases are drawn from the center toward the end. (*b*) Since the passage of the gases is transversely across the kiln they are compelled to pass through the centers of the cars and can not merely find their way longitudinally between the walls and the ware. For this reason cars of a much greater width can be used.

These results are achieved by using a multiplicity of burners on the two sides of the kiln, which are used alternately, the draft being switched from side to side at intervals. The sensible heat of the gases of combustion under these conditions cannot be used to preheat the ware, as in the longitudinal draft kiln, but instead is stored in regenerator chambers filled with checker brick and is recovered by preheating the air and the fuel when the direction of flow is reversed.

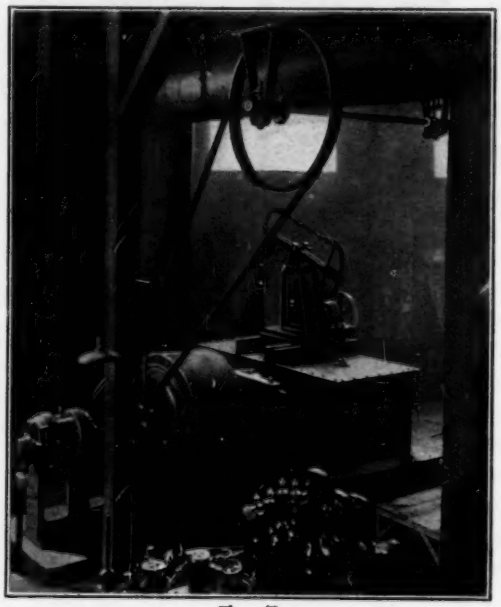


FIG. 7.

The problem of distributing fuel through a number of ports spread over a considerable length has fortunately been very thoroughly worked out in the design of by-product coke ovens and it has been possible to adapt the methods of the coke oven constructors very closely to the tunnel kiln.

The kiln from end to end is divided into a number of short sections, about 12′ 6″ long, each of which has its own independently regulated fuel and air supply and is operated strictly independently of the other sections. Such a kiln can be built in two different ways.

(*a*) With two trains of cars passing through in opposite directions, so arranged that the heat retained by the ware leaving the furnace zone is imparted to the ware entering it.

(*b*) With a single train of cars. In this case the heat of the ware leaving the furnace zone cannot be applied satisfactorily to the preheating zone but can be conveniently recovered as hot air and used for other purposes.

Figure 8 illustrates diagrammatically a kiln of the former type with two trains of cars, as adapted for firing silica brick.

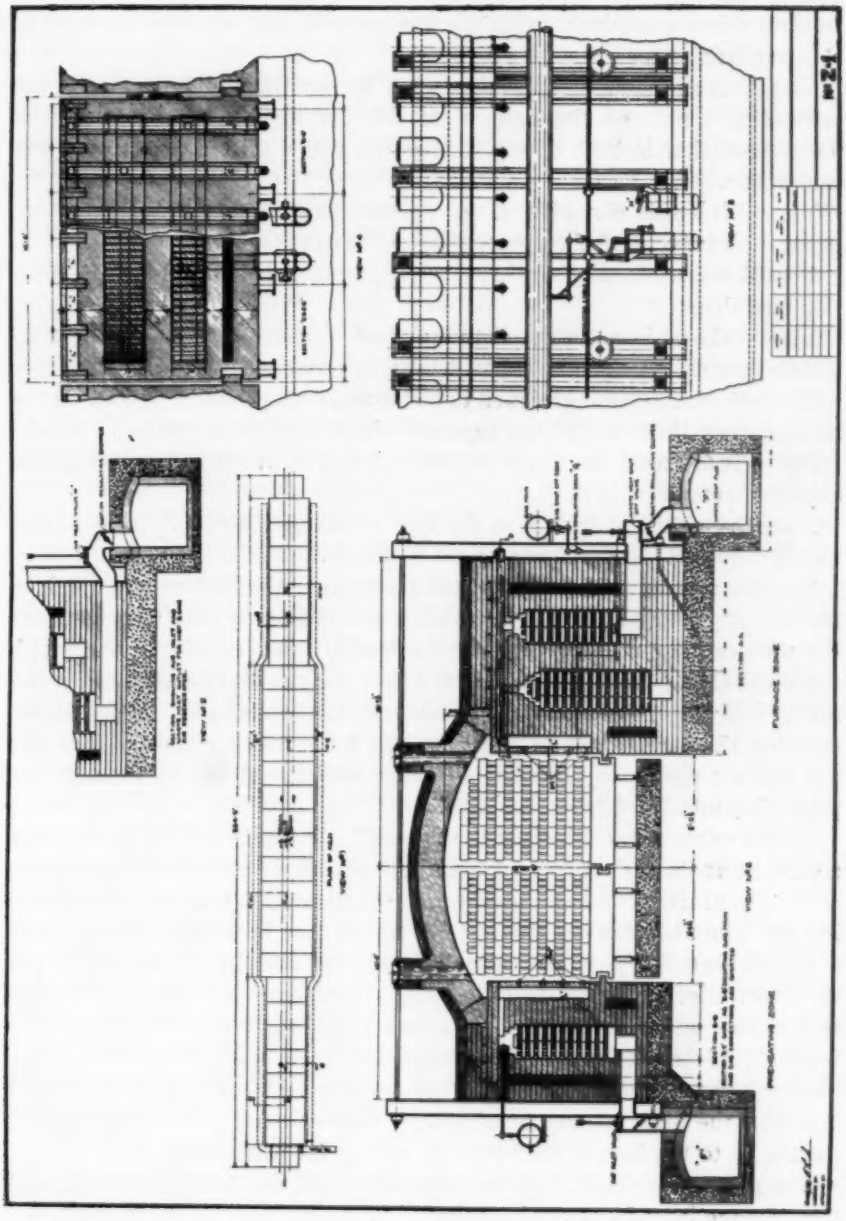


FIG. 8.

View 1 shows a plan, from which it will be noted that the kiln is divided into 27 sections, not counting the ante and post chambers. Of these sections thirteen are included in the furnace zone and seven at each end in the preheating zones.

View 2 is a double cross-section. On the left hand side is shown the preheating zone; on the right hand side the furnace zone. It will be understood that in both of these zones the kiln is symmetrical about the center line.

View 3 is a side elevation of one section showing method of operating gas and air valves and the connections to the exhaust ducts.

View 4 is a sectional plan through one pair of regenerators and combustion chambers.

View 5 shows in more detail the method of controlling the air inlet to the air regenerator and the exhaust from the latter.

The kiln illustrated is designed to be burned with producer gas and in the furnace zone there are shown separate air and gas regenerators. Where other fuels are used the gas regenerator is not required and only a single air regenerator is used.

Assuming that the draft is on the flue (F′) the gas cock (C) is open, and the air valve (H) is open (see views 2, 3, and 5).

The gas and air pass through their respective regenerators and out into the ducts (J) and (K) which bring them independently into the chambers (L) whence they pass out among the loaded brick on the cars through the ports (M). In the highest heat zones the gas and air pass out separately into the kiln chamber and mix and burn there, so as to avoid destroying the refractories of the kiln. In lower temperature regions the gas and air pass into the same chamber and emerge mixed through the ports (M) into the kiln.

On the other side of the kiln the flue (F′) exercises a suction on the two regenerators through the connections both of which are controlled by dampers. The draft is communicated to the chambers (L′) and the gases entering the kiln chamber on the far side are drawn back through the ware across to ports (M′). These ports are adjusted initially to give the proper distribution of draft and fuel from top to bottom. But further changes in their size and distribution can be made while the kiln is in operation by inserting or removing, through the openings provided in the crown, small blocks fitting in the ports. Since the ports are the same on both sides of the kiln, the draft at any level will be proportioned to the fuel and air passing in to the kiln at the opposite side on the same level.

The gases pass through the regenerators, heat up the checkerbrick and then emerge into the waste heat flue (F′).

After a predetermined interval the gas and air are cut off, the draft reversed to flue (F) gas and air turned on again at the other side of the

kiln. The process is then exactly the same but the gas stream passes in the opposite direction.

The mechanism by which these reversals are brought about simultaneously throughout the firing zone of this kiln is shown in view 3 and is one which has been used satisfactorily for years on by-product coke ovens.

On either side of the furnace zone the outgoing cars are heating up the incoming ones. In order to secure perfect heat distribution in this region a single regenerator chamber is provided on each side permitting a slight reversible draft to be maintained. A little gas is burned on the outside of the incoming car to insure its being heated evenly throughout. At the entrance end of the kiln chambers are provided in which the heat interchange between the two trains is carried out exclusively by the natural circulation of the atmosphere. It will be understood that relative proportions of these various zones can be varied to suit the circumstances.

In the case of the second type of kiln, where only one train of cars is used, the construction throughout the preheating zone is similar to that described save that the necessary amount of gas is burned on both sides of the kiln and some preheating can be done by displacing a proportion of the gases from the furnace section forward towards the entrance end. Only one set of regenerators, however, is provided in this region, the double regenerator system being confined to the furnace zone. In the cooling zone the same single regenerator construction is used but no fuel is burnt. The air passing in is preheated by contact with the checkers and strikes the brick on the cars at a temperature approximating their own. It passes out on the far side, heats the checkerbrick and escapes at relatively low temperature to the flue, which in this case is separate from the heating zone flue. In this way a very complete control of the rate of cooling in all sections can be obtained and where there is a need for large quantities of hot air for drying purposes this design is especially suitable.

The advantages of this cross-fired type of kiln can be summed up as follows:

(1) A kiln of great width can be built. It is felt that a width twice that of the ordinary longitudinal draft kiln is quite practicable. This enables the kiln length to be shortened and permits of large tonnages being fired in a single unit of practical length even when a very long cycle is necessary. The cross-section illustrated has 12 brick in the width. The pair of cars six feet long holds 3600 brick giving on 120 hour cycle a capacity of 42,000 per 24 hours for the 366-foot kiln.

(2) With regeneration of heat, the temperatures that can be reached readily are limited only by the failure point of the refractories of which the kiln is built.

(3) The kiln is, in essence, a series of independent short kilns, side by side. The conditions in each of these can be varied quite independently

of each other. In any section any desired atmospheric condition can be maintained, whether oxidizing or reducing, and in addition as much heating or cooling as is desired can be carried out.

Although the cross-fired regenerative type of kiln has principally been evolved to meet the condition of the silica brick industry, yet it is, of course, applicable to the firing of ordinary fire clay brick where very large tonnages, up to 200 tons per day, are required to be produced in a single unit or where only a short length is available.

Summary and Conclusions

For the heavy clay refractories the muffle type of kiln is best adapted owing to its inherent qualities of control and regularity of heat treatment.

For the fire clay fire brick the longitudinal draft direct fired kiln is indicated by its simplicity of design and cheapness of construction. The problems of firing this material do not seem to be beyond what can be successfully dealt with in this type of kiln.

For firing silica brick and other high fired refractories the cross fired regenerative kiln is best suited since it permits a practical volume of production on a long cycle, without extending the kiln to an inordinate length, and at the same time gives complete independent control of every stage of the heating up and cooling down.

1543 E. Boulevard
Cleveland, Ohio

EUROPEAN SILICA REFRACTORIES

By Sandford S. Cole[1]

ABSTRACT

This investigation was on the silica brick and shapes made in Europe and the ganister supplied for the same. Analyses of rock and brick produced according to American practice and in Europe from the same rock are given. The results of tests on the best grades of brick are given. A general conclusion is that silica brick manufactured in Europe is not satisfactory for use in coke oven construction with a few exceptions.

Introduction

In an investigation on silica refractories manufactured in England and on the Continent, certain points of comparison have been found which might be of interest to the American manufacturers and users of silica refractories. In this work, a thorough study was made of the brick and shapes of the principal European producers of silica and of the main sources of supply of ganister in order to make a comparison with American rock and brick and to show the quality of the ware and the possibilities of its safe use in coke and gas oven construction.

Test of European Ganister

The ganisters were first investigated in order to see if a good grade of brick could be produced when the rock was handled according to American practice. The rock was worked in 1000-pound batches in an American silica plant under the same conditions of manufacture as American silica brick. The brick produced were tested for strength, fusion, apparent specific gravity and load test to 1500°C.

The ganister used had the following analyses:

	A	*B*	*C*	*D*	*E*
SiO_2	98.16	98.54	97.54	96.52	98.00
Al_2O_3	0.72	0.61	1.19	1.94	0.93
Fe_2O_3	.67	.51	0.21	1.42	.54
CaO	.36	.03	.35	0.07	.07
MgO	.01	.01	.01	.09	.07
Alkalis	.07	.07	.16	.06	Trace
Ignition loss	.30	.48	.42	0.37	.29

The results of some of the tests made are given below.

	B	*C*	*D*	*E*
Fusion cone	30–31	30–31	31–32	31–32
Apparent specific gravity	2.354	2.338	2.357	2.362
Modulus of rupture in lb. per sq. in.	730	774	483	529
Per cent permanent expansion after load test to 1500°C	0.98	1.05	1.09	1.21

[1] Industrial Fellow, The Koppers Company, Mellon Institute, Pittsburgh, Pa.

The sample marked *E* made an exceptionally fine brick which on reheating to 1500°C became very nearly clear white in color. All the brick made gave a sharp ring when struck with a hammer. Only with *D* was there any difficulty encountered in production, it being inclined to stick to the molds and was rather plastic.

The following are the analyses of the brick. *D* and *E* were made using 10% "bats" from a batch in which no "bats" had been used.

	B	*C*	*D*	*E*
SiO_2	95.90	96.34	94.04	95.94
Al_2O_3	1.09	0.75	1.73	0.73
Fe_2O_3	0.80	.87	1.11	.79
CaO	1.89	1.93	2.92	2.45
MgO	0.06	0.21	0.14	0.11
Alkalis	....	....	.17	.11
Ignition loss	....	0.03	.02	.06
	99.74	100.13	100.13	100.19

Conclusions

It is possible to produce as good brick for coke and gas oven construction from these as can be produced in this country. The ganisters were very similar in appearance and structure to the Medina sandstone strata used in the production of a large portion of the silica brick in this country. The silica brick and especially that made from *E* was quite promising and gave evidence of a good grade of rock being at hand for use.

Foreign Made Brick

The brick and shapes manufactured in Europe were then investigated and in general the ware was of a fair workmanship and quality but the brick were not well bonded, were underfired and low in fusion point. In the investigation of ten manufacturers of silica brick there was found to be but two whose products were comparable with the American grades. The general cause of failure to meet with requirements was low fusion, high specific gravity and failure under load of 25 lb. per sq. in. The high specific gravity is an evidence that they either have difficulty in firing, or their kilns are not of proper construction to reach the temperature required to give a partial or complete inversion of the quartz to cristobalite and tridymite. The general value for the specific gravity was from 2.40 to 2.45 with a fusion point ranging from 29 to 31. A further proof of the low firing was in the permanent expansion in load test.

To see if this expansion was due entirely to underfiring, a reheat in kilns in this country was made and an expansion of nearly the same value as on load test was obtained. When these brick were subjected to load test and a low permanent expansion resulted, it proved that the brick had not been fired to a sufficiently high temperature.

The results on the satisfactory brick are partially given below.

	A	*B*
Fusion point	31–32	32
Apparent specific gravity	2.38	2.329
Permanent expansion on load test to 1500°C	1.73%	0.36%
Permanent expansion on load test to 1500°C (after reheat in commercial kilns)	0.55	..
Modulus of rupture	537	377

CHEMICAL ANALYSIS

SiO_2	94.36	96.52	MgO	0.11	0.07
Al_2O_3	2.16	0.51	Alkalis	.28	.17
Fe_2O_3	0.69	0.49	Ignition loss	.49	.04
CaO	1.68	2.02			

These two sets of brick were quite similar in color and in other properties to American made brick. The brick was produced from *B* ganister and had an exceptionally smooth surface and sharp lines due to the molds used by the manufacturers. The results on these brick give a concordant value with those usually had on American made brick. The analysis is quite similar with the average of the Eastern silica brick. The one low

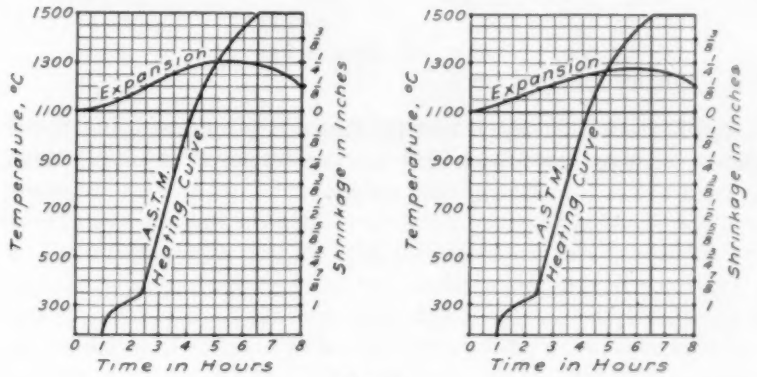


FIG. 1.

modulus of rupture has probably been caused by a weakening of the brick by rough handling in transportation.

The general conclusion drawn from this investigation is that the European silica users have a lower standard than the American. There was found to be a general tendency toward Dinas and quartzite brick quality and class. Some of the brick and shapes gave quite conclusive evidence that they were bonded with clay. Then, too, the ganister used may have some effect as there are quarries which do not produce as good a grade of rock as those which were tested.

Silica Cement

Two silica cements were also tested. The results of the screen test, fusion, and change in firing to cone 15 and 20 are given here.

Screen test	*A*	*B*
On 20-mesh	....	....
48	1.67%	17.4%
100	8.80%	20.0%
200	8.85%	13.3%
Through 200	80.68%	49.3%
	100.00%	100.0%
Fusion cone	19	31
Drying shrinkage		1.3%
Firing shrinkage, cone 15	....	0.0%
cone 20	....	+1.8%

Both were quite plastic but the fineness of grind of *A* caused the low fusion point. *B* was quite similar to the American cement in both screen analysis and appearance.

Screen analysis (100 samples avg.) of American made silica cement shows:

Mesh	Per cent	Mesh	Per cent
On 20	..	On 200	12.0
On 48	20.0	Through 200	38.0
On 100	30.0		

Although *B* was rather fine it met the fusion requirements, and the slight expansion from wet to fired length at cone 20 makes it entirely possible to be used to set up silica in coke ovens.

SOME DATA ON THE PULSICHROMETER[1]

By Robert Galbraith

ABSTRACT

A table has been worked out of the plate openings necessary to use with enamel and slips of different weights reducing the skill required to obtain a smooth coating on a piece. The apparatus is described and tests were run on varying materials, *viz.*, raw materials, fritted enamels and slips. The theory is advanced that the large orifice fails to develop enough back pressure to give the enamel sufficient velocity through the tube. Other features of the pulsichrometer are discussed.

It is recognized by operators of the pulsichrometer that when a slip of relatively low specific gravity is used with an enamel of a higher specific gravity, the slip will precede the enamel when going up a perpendicular piece, whereas the slip will follow the enamel when the direction is reversed. On the suggestion of M. E. Gates a table has been worked out of the orifices or plate openings necessary to use with enamels and slips of different weights in order that "following" may be eliminated. This reduces the skill and care required to obtain a smooth, even coating on a piece.

Table I shows the diameters in inches of the standard plates used.

No. of Drill	Inch Diam.
70	0.028
65	.035
60	.040
57	.043

There is a difference of 0.015 inch between the largest and smallest drill hole. This will be shown to have a weighty influence upon the action of the machine.

The set up of the apparatus to work out these orifice relations is shown in Fig. 1. The machine was fastened rigidly to one end of a shaft by set screws. The shaft was then fitted to a collar which held it securely. At the opposite end of the shaft a circular disk was mounted which was free to revolve about the shaft. This disk was made to revolve at a fairly uniform speed of 216 r.p.m. The machine was operated at a constant speed of 800 r.p.m. as that is the average speed used by the machines in the slipping department.

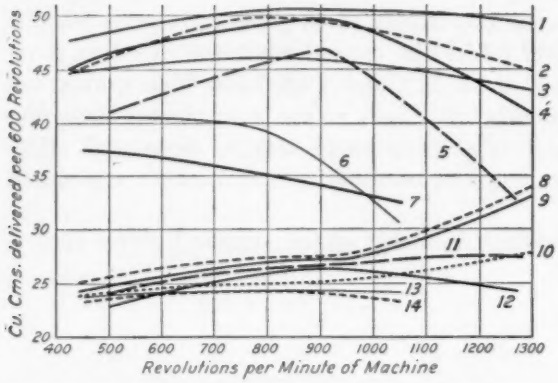
Sheets of unexposed blue print paper were cut round to fit the disk. The disk was set in motion and the enamel sprayed upon it. Every spot of enamel left a white mark on the paper, which of course turned blue after exposure to light, and in this way a permanent record was obtained.

The average distance from the center of the spots to the center of the chart was then measured and the specific gravity and flow of the material

[1] Presented at the Atlantic City Meeting, February, 1924 (Terra Cotta Division). Received September 24, 1924.

noted. The specific gravity was obtained by weighing 100 cc. of the material. The flow was measured by means of a flowmeter. This flowmeter was a cylinder of $2^1/_8$ inches diameter and 7 inches length at one end of which was a cylindrical tube of $^3/_{16}$ inch diameter and 6 inches length. At the other end of the cylinder there was a hole of $^3/_8$ inch diameter.

A wide variety of materials was used, the list consisting of three fritted enamels, two raw enamels, a fritted glaze, and three slips. After running materials of certain viscosity and specific gravity they were thickened with acetic acid which gave slower flow with but a slight change in specific gravity. The material was then thinned down with water to the same flow it had before the addition of acid. A series of four standard plates was used for each setting of the material.



Curve	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plate	None	57	70	57	70	57	70	None	57	70	57	70	57	70
Hose	4	4	4	4	4	4	4	3	3	3	3	3	3	3
Flow				45	45	71	71				45	45	71	71
Material	Water			Slip		Enamel		Water			Slip		Enamel	

FIG. 1.

After making a number of these charts it was realized that the speed of the machine was probably as large a factor as anything else in determining the height at which the material would strike a piece. Consequently some delivery data was obtained. The machine was set at different speeds, noted by the use of a stop watch and a speed counter applied to the end of the shaft which operated the pedals. After obtaining the speed, the material delivered for a certain number of revolutions was obtained by catching it in a test tube and weighing it, measuring the specific gravity of the material and dividing it into the weight delivered, calculating the cubic centimeters. Curves were plotted using the revolutions per minute of the machine as abscissas and the cubic centimeters delivered as ordinates. Upon comparison of these curves with the ones obtained with the machine running at constant speed, it was decided to concentrate most of our attention on the latter experiments as these seemed to show more clearly just what does occur in the pulsichrometer.

As a consequence of this decision this chart has been prepared (Fig. 1). You will observe that three materials have been used, water, slip, and enamel. Two hose have been used with the respective diameters $^3/_{32}$

and $^1/_8$ inch for number 3 and number 4. The areas of the hose calculated in square centimeters are .0445 and .0792. The orifices used were numbers 57 and 70, .043 and .028 inch in diameter.

There are several interesting facts shown by these curves and I have endeavored to derive a theory for most of the more unusual features. The intersections of the curves show the speed at which to run the machine in order to have the same quantity of material delivered using the plates and hose indicated. These points were all checked by actual experiment. The highest points of the curves should be the ideal speed at which to operate the machine in order to gain a maximum output, enabling the operator to finish a piece more quickly. These points were also checked. One interesting point on the chart is the intersection of the curves for the enamel using a number 4 hose with plates number 57 and 70. My own tentative theory to account for this is that the larger orifice fails to develop enough back pressure to give the enamel sufficient velocity through the tube.

Another interesting feature is the close proximity of the points for the different plates when a No. 3 tube is used. This must be due to the diameter of the hose being so nearly the same as the diameter of the orifice. The fact that at high speeds all the curves (except those using water in No. 3 hose) decrease in height must be due to the rapidity with which the pedal strikes the tube, not allowing a sufficient interval of time to elapse for the hose to fill up before an expulsive action occurs.

The convexity of the curves for water using a No. 3 hose apparently indicates the water has sufficient velocity in the tube to allow it to completely fill between impacts, thus causing the amount delivered to vary directly with the speed. It is regrettable that the machine could not be operated at a sufficiently high speed to determine the maximum for this curve.

Discussion

MR CLARE:—Did you make these experiments because you were getting variations?

MR. GALBRAITH:—We wanted to see if we could not stop this shooting up of the slip. I started out to get up a table using two different materials with varying specific gravity and viscosity of flow to see if we could arrange a series of plates so they would all hit the same, so that a piece could be worked up or down or sideways without variation.

MR. CLARE:—Would that variation change the character of the texture you were making?

MR. GALBRAITH:—Very much. If one man should get a sudden notion to go down on a piece while the other man was going up, one piece would be very dark while the other piece would be light. You would have great variation.

MEMBER:—What is the density you use on vases?

MR. GALBRAITH:—1.75 grams per cc. and for raw enamels we usually set around 1.7 grams per cc.

MR. RADCLIFFE:—I have used it in various ways and with a slip in the middle. The slip did run ahead. When we first got the machine we were instructed to use it any old way and that it would work, but we found that in order to produce a uniform color we had to go the same way all the time. If a sprayer started at the bottom of a piece and went to the top he would get just about the same color. However, if he shot at an angle he got long streaks, whereas if he held the machine so it shot directly at a piece he obtained more uniformly shaped spots.

We have used it mostly with a slip in the center hose and a glaze in the outside hose. I think if you use two glazes or two slips you have less trouble from variation of color than you do by using a glaze and a slip.

It gives good results providing you keep it in good shape. The pulsichrometer, in order to work properly, must be gone over practically every day and cleaned and oiled up. If your spots vary it is for the simple reason that the glaze does not flow through your hose fast enough to fill it up before these plates come up and squeeze the hose. The hose does not have time to fill up if your machine is running too fast and you may get more of the slip spots than you want. If it runs at a fair speed it does very well.

MR. SCHEPERS:—I have personally run a machine for six months using it day in and out, for three or four hours at a time. The machine has never been taken down and I never took the plates off or have never had any trouble with it. When I got through with it, I shot some water through and laid it over on the side. I have never had any experience where the machine should be oiled or cleaned every day.

MR. STRUSHOLM:—We have four of those machines working at the South Amboy Terra Cotta Company and if the man using a machine does not clean it, it delays us some minutes before we can get it to working. If you leave the pressure on, the small hole closes up entirely and there is only one remedy and that is to cut a piece off. You never saw a piece of machinery from an automobile to a threshing machine that did not want cleaning and care and oiling.

MR. HOTTINGER:—It seems to be but a precaution to always put a machine away in such shape that it can be used the next day and also to take care of it.

MR. STRUSHOLM:—We were told that these machines would break down every day. We have used them for a year and the only breakdown we had was because one of the men let a machine fall and did not report it.

SYNTHETIC SILLIMANITE IN CERAMIC BODIES[1]

By T. S. Curtis[2]

ABSTRACT

The manufacture, characteristics, and use of a new ceramic product in which the stable form of sillimanite, having a composition of $3Al_2O_3$–$2SiO_2$, is the chief constituent. An interesting feature of the product is the fusible matrix of definite composition, in which sillimanite needles are held, and which permits of recrystallization at commercial temperatures when the product is added to porcelain or whiteware body mixes. Introduction of sillimanite apparently greatly toughens and strengthens the body in which it is introduced.

Introduction

When the Research Division of the Vitrefrax Company started an investigation of the properties and possibilities of sillimanite, the literature was meager and of doubtful practical value. Since that time, much work has been done with this remarkable compound, and during the past year a number of valuable papers have appeared on the subject, chiefly, if not wholly in the *Journal of the American Ceramic Society*. It is proper to make acknowledgment to those able and zealous workers of the Bureau of Mines at the Northwest Experiment Station for their practical help in this field, also to the investigators of the Geophysical Laboratory.

Early Investigations

Our experimental work has covered what we believe to be every known form of sillimanite. Andalusite, cyanite, and natural (Indian) sillimanite have been used, as well as every conceivable artificial mixture, from chemically pure aluminum oxide and pure crystal silica, to the diaspores and bauxites.

In every case, we have found heat treatment to change the mineral or the mixture into a mass of crystals having a composition of 71.8 alumina to 28.2 silica. This represents a molecular ratio of $3Al_2O_3$–$2SiO_2$. This fact was determined first by carefully removing the needle-like crystals from our first ingots with tweezers and analyzing them chemically. In the heart of every ingot having approximately a 1:1 ratio as charged, there will be abundant masses of these crystals.

We then found that near the matrix from which the needles grew apparently a sheath of glass covered the crystals, changing their apparent composition to one between 3:2 and 1:1. Small bundles of crystals were then placed in cold hydrofluoric acid for several hours to dissolve the glassy sheath. The cleansed crystals then showed a ratio of exactly 3:2 on chemical analysis.

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[1] Presented at the Summer Meeting, Los Angeles, Calif., October 6, 1924.

[2] Director of Research, The Vitrefrax Company, Los Angeles, Calif.

We followed by sintering at cone 36 an intimately ground mixture of alumina and silica in the ratio of 1:1, after which the ground sinter was leached with hydrofluoric acid as before. The washed residue analyzed 3:2 in ratio.

Our slowly dawning conclusion that the stable compound of alumina and silica was something other than what we had learned from the published curves was confirmed very quickly when refractory brick were made from the various melts. The 3:2 brick were strong and rigid under loads at high temperature, while those having a composition of 1:1 were not able to bear loads as well as a good fire brick, although the melting point of cones made of the two melts was about the same.

Ceramic and Refractory Sillimanite

The results of this early work quickly showed that there might be two entirely distinct and valuable uses for sillimanite. One, as a refractory, in which the ratio of the entire product would have to be 3:2 while the other, a development of sillimanite 3:2 crystals in a matrix of rather definite composition, might have important applications as a ceramic material.

The refractory grade was found to be entirely too refractory to be satisfactory as an ingredient in ceramic bodies, since it consists chiefly of 3:2 crystals and corundum plates. By firing a porcelain body at excessively high temperatures, probably the same results could be obtained as with the ceramic grade of material. But this was considered to be impracticable. Our problem was therefore to so combine as to permit the formation of an easily fusible glass of definite and controllable composition in which an abundance of 3:2 sillimanite crystals would grow as the melt cooled. The theory was that in such a product, when combined with a typical ceramic body mix, the glass would readily melt into the body, forming an addition having the same function as feldspar, and permitting the sillimanite crystals to grow anew and to interlock in a tangled mass within the body.

The problem was simple insofar as making a fusible glass was concerned; practically any ratio from that of kaolin to near that of 3:2 sillimanite would give it. But in nearly all of these mixes great difficulty was experienced in removing microscopic pellets of metallic impurities which spotted the ware made from the product.

Finally, however, a composition was evolved which gave precisely the characteristics desired, and it was found that by a very careful control of the raw mix and of the subsequent furnace operation, a remarkably consistent and uniform product resulted.

It is an interesting commentary on the mysteries with which the compound called sillimanite surrounds itself to note that chemical analysis of the finished product does not in any way suggest how to duplicate it,

for the composition of the raw mix bears very little resemblance to the melted and crystallized material coming from the furnace. It was this feature of the work that caused the investigators seemingly endless effort before a controllable product materialized.

After the final product was evolved, it was found that due to the reducing atmosphere under which it formed, slight traces of free alkali would persist after crushing and grinding. This alkali would act as a deflocculant in many bodies to which the grain was added, serving in some cases utterly to destroy the plasticity of the body. A treatment has been developed to eliminate this troublesome feature entirely so that the addition of the finely ground product has no more effect than so much feldspar or flint on the working properties of the body.

The removal of entrained metallic impurities offers perplexing problems. We very quickly discovered that the addition of metallic iron to the charge to render the particles of reduced silicon magnetic would ruin the color of the final product, for, contrary to the prevailing opinion, we found that sillimanite would take up and hold in solid solution sufficient iron to turn the crystals deep amber color when they are oxidized.

We have found that by a decidedly limited raw mix composition and certain method of furnace operation in which the power input per pound of charge fed into the furnace is controlled within close limits, we can make even the microscopic shot of silicon magnetic so that they may be removed by powerful, high intensity magnetic concentrators after the product is ground.

How Product is Used

In order that the peculiar value and effects of this product may be understood, we shall use as illustrations some familiar applications of the principle of fibrous aggregates that may cause some of our learned members to smile; the principle is so beautiful in its simplicity and strength, however, that we must make certain that it will be understood, even by those to whom sillimanite is quite unknown.

If you will let your minds slip back to the historic days when unbaked brick were made with straw; if you will recall that the plasterer admixes hair with his plaster, and those of you who make terra cotta will surely picture how frail a plaster mold without its fibrous aggregate would be; if you will think of the value of asbestos fiber in many cold and hot cements; and finally of the strength which is imparted to common concrete by the interlacing network of steel fiber within it; and then think of the cement which binds concrete as a mass of millions of tiny interlacing crystals so entangled as to impart not only great rigidity but toughness to the bonded mass of aggregate, then you will in a measure visualize the function of sillimanite in a ceramic body.

As any mixture of alumina and silica with fluxes is brought up to a temperature where the mass, or at any rate that part of the mass in contact with the impurities, becomes viscous or fluid, a small percentage of the body will become liquid. As this liquid cools, tiny needle-like crystals of sillimanite will grow in the congealing fluid, just as salt crystals grow out of a cooling and evaporating solution of salt in water. We have every reason to believe that much of the strength and toughness of porcelains is due to this interlocking network of sillimanite fiber which develops in the body on cooling.

But in the common porcelains, a very small amount of sillimanite is formed for the reason that the firing temperatures employed do not take more than the matrix surrounding the crystals of kaolin and of flint into solution. We have found that on melting ordinary fire clay, an abundance of sillimanite crystals appear in the melt after it has cooled. Therefore it is reasonable to expect that if it were possible to fire an average porcelain sufficiently high, a very much larger percentage of sillimanite would form in it. However, that treatment would hopelessly ruin the ware, since there would not be nearly sufficient sillimanite-forming ingredients in the body to cause it to retain its shape in the firing.

The answer must be apparent. In order to produce a piece of ware in which great strength and toughness are indicated, we must build the foundation or skeleton of that body of a mass of strong, tough fibers having a very low coefficient of expansion, preferably building up such a percentage of the needle-like crystals that the latter will interlace and interlock. Then we must fill the interstices of this fibrous mass with a bond in which still more fibers will grow in ever decreasing size as the voids decrease.

The new ceramic product we have described has just this for its function. Rich in pure sillimanite crystals, yet imprisoned in a matrix which permits a ready blending and solution with the ball clay and china clay of the bond at temperatures within commercial reach, acting in itself as feldspar in the high fire bodies, and combining readily with the feldspar in those compositions designed for lower firing temperatures, the product offers extremely interesting and important fields of investigation by makers of porcelain and whiteware bodies.

The electrical properties of the product are excellent and its use in many forms of electrical insulators seems assured once its properties are understood.

While no work has been done with the product in the manufacture of glazes, it appears to offer possibilities if one may judge by its behavior in refractory cements designed to glaze or flow at furnace temperatures. When admixed with ball clay and feldspar and applied as a wash to fire brick, a fine, tough glaze is formed at slightly above cone 20. This glaze

appears to resist mechanical injury very well after cooling and shows no tendency to craze when applied either to siliceous or aluminous clay brick. It is to be expected that an element of toughness would be introduced in glazes through its use.

In itself, sillimanite appears to have practically no covering power as an opacifier, although it has been used as such in opal glass, so we are informed. The crystals are clear and colorless, while the streak is white.

It would therefore appear as though the product could be used in either transparent or opaque glazes, although in the former the tendency to crystallize in a myriad of satin-like needles may mitigate against its use. We have observed in the refractory glaze previously referred to, only a slight tendency to show this satin appearance to the naked eye, while under the microscope, the apparently transparent glaze is really a mass of fine, hairline needles, apparently distributed in the utmost confusion.

The use of synthetic sillimanite of the ceramic type in balls for pebble mills as well as in the linings has been shown to have a truly practical value. In the fine grinding of the product, we use Durox balls exclusively. We have used pieces of the furnace ingot, which form in pebbles in the large mills at times, for months of continuous grinding with practically no measurable wear. If it were commercially possible to produce these pebbles in quantities at a reasonable cost, the flint pebble would be driven from the market, as the sillimanite pebble has a specific gravity of 3.1 against about 2.6 for the flint, and its wearing qualities are amazing.

While the bonded sillimanite does not have quite the wearing qualities, nor has it the specific gravity of the original ingot ball, it nevertheless shows such an increase in grinding efficiency that its use to the exclusion of flint pebbles seems fully justified.

The introduction of this new form of sillimanite product does not adversely affect the color of a white body when the addition is made of the specially treated ceramic grade of material. The burning color is pure white.

Ceramic Sillimanite Made Commercially

The product we have described is well out of the experimental stage insofar as its manufacture is concerned. It is produced in a plant having a daily capacity of 20,000 pounds of which capacity approximately one half is now utilized. The raw material resources guarantee uninterrupted production entirely independent of any foreign material. The uniformity of the material is remarkable, due to the close control necessarily exercised in its manufacture.

The use of the product is, however, entirely in the experimental stage, with the exception of two commercial applications which have proven so successful that a steadily increasing tonnage is being manufactured.

The results that may reasonably be expected from the introduction of sillimanite into many ceramic bodies are of such moment that it would seem to justify considerable investigation on the part of whiteware makers, porcelain insulator manufacturers, and other ceramic workers who desire to impart considerably greater strength and toughness to their wares. To this end, the manufacturer of the specially prepared ceramic grade of sillimanite which has been described in this paper, will be glad to furnish samples for experimental purposes to any manufacturer who is interested.

METHOD FOR THE ANALYSIS OF ALUMINOUS SILICATE REFRACTORIES[1]

By Edward P. Barrett[2] and Frederick W. Schroeder[3]

ABSTRACT

A method is given in which the solution of difficultly fusible refractory material is obtained by subjecting the finely pulverized material to two fusions, the first in sodium carbonate, followed by one in potassium bisulphate. The melts are dissolved in water and after adding sulphuric acid are evaporated to dense fumes. Care is taken to remove any calcium sulphate that may be formed. The final residue is treated with hydrofluoric and sulphuric acids. The alumina is determined according to the method described by Blum as given by Hillebrand especial care being used in heating the final precipitate to constant weight. A temperature of about 1150°C is necessary. Two precipitations are required in the determination of lime. The excess of ammonium salts are removed prior to the precipitation of the magnesia, by adding an excess of nitric acid, evaporating to dryness and heating, which expels the ammonium chloride according to the reaction $NH_4Cl + HNO_3 = HCl + 2H_2O + N_2O$.

Introduction

The analysis of fused clays and artificial sillimanite is a difficult problem due to the infusibility of these substances with any of the common fluxes. Samples of fused clay and artificial sillimanite, ground to pass 300-mesh, were mixed with ten to thirty parts of sodium carbonate in a platinum crucible and heated over a blast lamp for as long as five to six hours. These melts were cooled and taken up with hot dilute hydrochloric acid. In every case there remained a residue of unfused material. In a number of cases this residue was pulverized in an agate mortar, mixed with sodium carbonate in a platinum crucible, and heated over a blast lamp for over an hour. Upon cooling and taking up with hydrochloric acid there appeared to be as much residue as before the second fusion. Attempts to obtain fusions with potassium carbonate, with mixtures of sodium and potassium carbonates, and with potassium bisulphate were equally unsuccessful. A two-fusion method was suggested in which the material was fused in a platinum crucible with potassium bisulphate, the melt cooled, taken up with hydrochloric acid, filtered, and the residue ignited and fused with sodium carbonate. A few trials showed that an unfused residue remained after the second fusion.

The pulverized fused clays and artificial sillimanites are easily fusible in sodium peroxide in iron, nickel, or silver crucibles but alumina cannot be determined in solutions obtained from fusions in sodium peroxide in iron or nickel crucibles because of the large amounts of iron or nickel taken into solution. It is difficult to remove silver from the silica in solutions

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[1] Published by permission of Director U. S. Bureau of Mines.

[2,3] Assistant Metallurgist and Junior Chemist, respectively, Northwest Expt. Sta. (Seattle, Wash.) of the Bur. of Mines. In coöperation with College of Mines, Univ. of Wash.

obtained from the fusions in silver crucibles. Then, too, any silver remaining in the silica might alloy with the platinum crucible during the ignition of the silica and alumina precipitates. The life of the silver crucibles is short, about ten fusions being all that can be obtained from each crucible. A satisfactory method using peroxide fusions in silver crucibles was perfected. Its use was discontinued because of the large number of manipulations required.

Fusions in mixtures of borax and sodium carbonate were suggested. Borax glass was prepared by fusing C.P. borax in a platinum crucible and pouring the melt onto a polished iron plate. Two or three grams of this borax glass added to ten to thirty parts sodium carbonate are sufficient to give perfect fusions in about thirty minutes heating over a Meeker burner. The only objection to this method is that it is very difficult to remove all of the borax, which contaminates both the silica and the alumina.

A satisfactory method was finally worked out in which the refractory material is subjected to two fusions, the first in sodium carbonate, followed by one in potassium bisulphate. The complete methods for the analysis of refractory ceramic materials follows.

Procedure

Fusion Mix 0.5 gram of the refractory material, ground to pass 200-mesh with about five grams of sodium carbonate in a platinum crucible and heat for twenty to thirty minutes over a Meeker burner. Take up in water and dilute sulphuric acid. Filter, ignite and fuse in several grams of potassium bisulphate. If considerable gelatinous silica is left after the sodium carbonate fusion, it is well to fuse in more of this flux before using the potassium bisulphate for the silica is liable to form a protective coating on the unfused material. The leachings from these various fusions are combined and about 10 cc. sulphuric acid added to the whole.

Silica Evaporate on the hot plate until copious fumes of sulphur trioxide are evolved. After cooling add about 200 cc. of water and boil for several minutes to insure the complete solution of calcium sulphate. Filter off the residual silica and wash well with hot water. Repeat this dehydration to remove the silica completely. Ignite the silica residues in an untared platinum crucible and weigh. Treat the residue with several cc. of hydrofluoric acid and one or two drops of sulphuric acid; evaporate and ignite. The silica is completely volatilized as silicon tetra fluoride, leaving the impurities in the form of the non-volatile oxides of alumina, iron, titanium, etc. The loss in the weight of the crucible and contents represents the actual weight of the silica.

Fuse the non-volatile residue in a small quantity of potassium bisulphate and add to the filtrate from the dehydrations.

Alumina and Iron[1] To the combined filtrates from the silica determination, made up to 400 cc., add approximately 10 grams of ammonium chloride, heat to boiling and add ammonia slowly until just alkaline to methyl red. Boil for a few minutes and then filter hot. Wash the residue several times with a 2% solution of ammonium chloride.

Evaporate the filtrate (No. 1) to a small bulk on hot plate. Digest the precipitate in 1 : 1 hydrochloric acid and reprecipitate exactly as before. Evaporate the filtrate (No. 2) from this precipitation to dryness and heat to expel ammonium salts. Take up the residue with hydrochloric acid and add it to filtrate No. 1. Add a little ammonia and continue evaporation to coagulate the last traces of iron and aluminum hydroxides. Filter and wash this small precipitate with a 2% ammonium chloride solution and add it to the main one.

Ignite to constant weight in a tared platinum crucible the combined precipitates of iron and aluminum hydroxides in an electric muffle furnace at 1150°C.

Determine the iron and other constituents by any of the well-known methods.

[1] The method used for this determination is essentially that of Blum, as given by Hillebrand. W. F. Hillebrand, "The Analysis of Silicate and Carbonate Rocks," U. S. Geol. Surv., *Bull.* **700** (1919).

ENAMELING DEFECTS DUE TO THE CAST IRON[1]

By A. Malinovszky

ABSTRACT

Troubles in manufacturing sanitary enameled ware are pinholing, breaking out, blistering, crazing, chipping, lifting, black specks, etc., due to the iron, the chemicals, methods of applying the slush or enamel, furnace temperatures, inexperience, lack of cleanliness, differences of the coefficients between iron and enamel and fitting of ground coat to the enamel, etc. Feldspar is most liable to cause trouble by variations of its constituents. Feldspar containing above 69% of silica should be looked upon with suspicion. Troubles arising from the cast iron are discussed. Results of chemical analyses and microscopic examinations and microphotos before and after enameling are shown.

Chips and lifts are caused by globules and patches in the castings due to some of the metals passing through the cupola unmixed. Segregations of the graphitic carbon even in minute state produce blistering especially if the graphitic carbon is present in laminar form.

Blisters, if caused by the iron, seem to be governed by the condition and size of the graphitic carbon. The presence of slag or dirt in the castings or at the surface of the casting also can cause chipping, lifting, black specks and blisters.

A certain southern pig iron has produced segregations of laminar graphitic carbons which constantly gave blistering, chipping and lifting. No mixture of irons with this southern iron would be free from these defects. Microscopic examinations of blistered ware revealed black spots (patches) on the castings where the blistering occurred.

Samples of blistered ware were prepared for microscopic examinations and also for chemical analyses before and after the ware had been enameled in order to compare the two samples and to determine what had taken place in the iron. The samples which showed laminar graphitic carbons before enameling showed black spots after enameling where blistering had occurred.

Chemical Analysis

In order to show the changes taken place during heating of the castings, three tubs were selected, one 5 foot roll rim, one 5 foot flat rim and one 5 1/2 foot flat rim. Drillings for the chemical analyses were taken from the rim, side and bottom. After enameling the drillings were taken 1/8 inch from the place where the first drillings were taken. The results are the following:

Analyses of Cast Iron before Enameling

5 ft Roll Rim Tub:	T.C.	G.C.	C.C.	Si	Mn	P	S
Rim:	3.408	2.454	0.954	2.572	0.502	0.729	0.0685
Side:	3.545	2.727	0.818	2.544	0.506	0.728	0.0672
Bottom:	3.545	2.863	0.682	2.509	0.513	0.731	0.0679

[1] Presented at the Summer Meeting, Los Angeles, Calif., Oct. 6, 1924.

5 ft. Flat Rim Tub:							
Rim:	3.436	2.672	0.754	2.486	0.487	0.731	0.0752
Side:	3.408	2.590	0.818	2.563	0.491	0.735	0.0748
Bottom:	3.545	2.808	0.737	2.544	0.492	0.733	0.0760
5½ ft. Flat Rim Tub:							
Rim:	3.572	2.372	1.200	2.516	0.476	0.734	0.070
Side:	3.517	2.372	1.145	2.52	0.478	0.735	0.0692
Bottom:	3.545	2.427	1.218	2.48	0.487	0.738	0.0688

ANALYSES OF THE CAST IRON AFTER ENAMELING

5 ft. Roll Rim Tub:							
Rim:	3.599	3.081	0.518	2.499	0.502	0.711	0.0683
Side:	3.517	3.136	0.371	2.507	0.506	0.713	0.0679
Bottom:	3.626	3.054	0.572	2.53	0.513	0.72	0.070
5 ft. Flat Rim Tub;							
Rim:	3.545	3.108	0.437	2.48	0.465	0.731	0.0713
Side:	3.408	3.381	0.027	2.499	0.468	0.734	0.0739
Bottom:	3.463	3.245	0.218	2.544	0.468	0.733	0.0726
5½ ft. Flat Rim Tub:							
Rim:	3.517	2.563	0.954	2.51	0.472	0.706	0.0692
Side:	3.599	3.217	0.382	2.479	0.472	0.706	0.0696
Bottom:	3.490	3.190	0.200	2.488	0.480	0.709	0.0670

One tank lid had been drilled on both ends before enameling. Analyses of the two end drillings gave the following results: Only the carbons had been determined.

	T.C. Before	After	G.C. Before	After	C.C. Before	After
End 1.....	3.408	3.545	2.699	3.217	0.709	0.318
End 2.....	3.408	3.545	2.699	3.217	0.709	0.328

This lid caused no blistering.

Microphotographs

Fig. 1. The sample was taken from a blistered and chipped tub. Carbon occurs abundantly as graphite in large curved crystals. These are shown clearly in the photograph. The bulk of the sample is pearlite, free cementite occurs in minute needles and narrow bands separating the patches of pearlite or cutting through them. Some of the cementite shows a honeycomb eutectic growth.

Fig. 2. Cross-section of the same tub as Fig. 1. Graphite crystals mostly their flat side parallel this face. Some show the curved lines but these are not so abundant as in Fig. 1. The form and relation of the pearlite and cementite is the same on this face as on Fig. 1 except for direction of the graphite crystals. There is no difference between the two faces of these samples.

Fig. 3. This shows graphite in small curved flakes which intersects the face at all angles. They are smaller than in Fig. 1. Free cementite is slightly less than in Fig. 1, and the texture is coarser. The cementite

FIG. 1.—Unetched, showing graphite crystals.

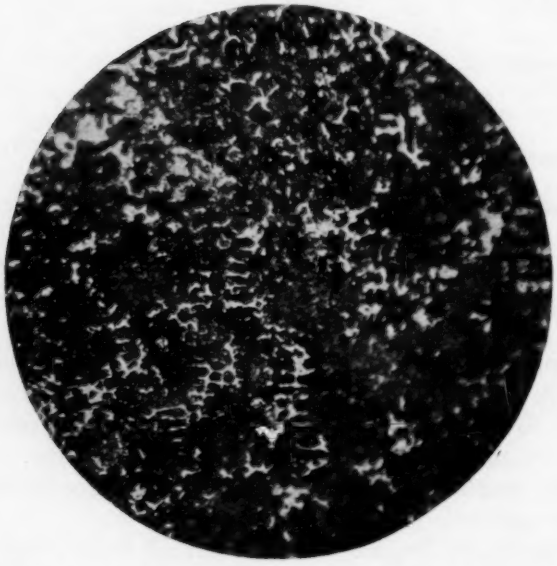

FIG. 2.—Etched, shows cementite (white) with honeycomb structure, pearlite (grey).

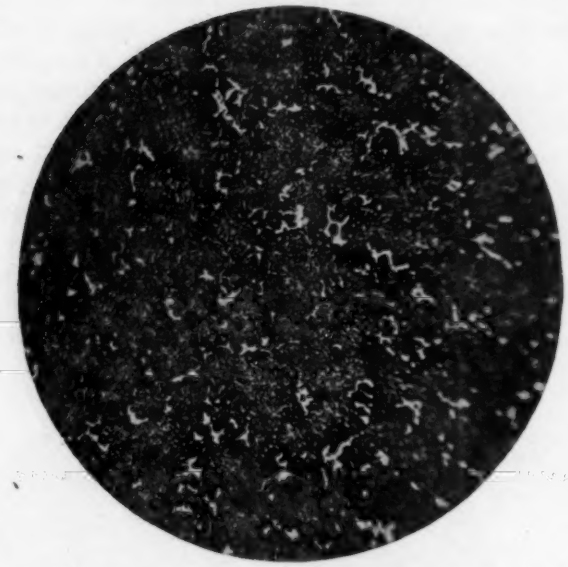

FIG. 3.—Etched, cementite (white), pearlite (grey).

FIG. 4.—Unetched, shows graphite.

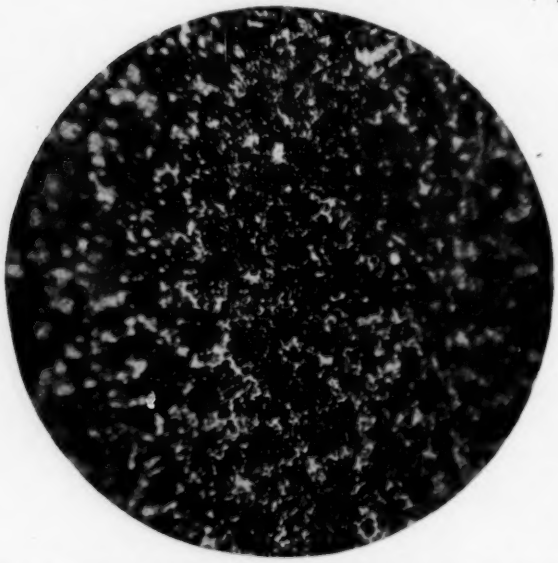

FIG. 5.—Etched, cementite needles (white), pearlite (grey).

FIG. 6.—Faintly etched, shows mottling appearance, blotches of temper carbon.

not being so evenly and finely distributed the pearlite is distributed accordingly in large patches. This iron had given no trouble with blistering, and is perhaps a very good iron for enameling.

Fig. 4. Graphite is very abundant in large curved crystals as shown. Free cementite occurs very abundantly in groups of minute needles forming narrow bands between the pearlite patches. This sample was taken from a blistered tub.

Fig. 5. Of the same tub showing the patches where the blistering occurred.

Fig. 6. The carbon in this sample is grouped in small round segregations of very minute flakes which, when the surrounding pearlite is deeply etched,

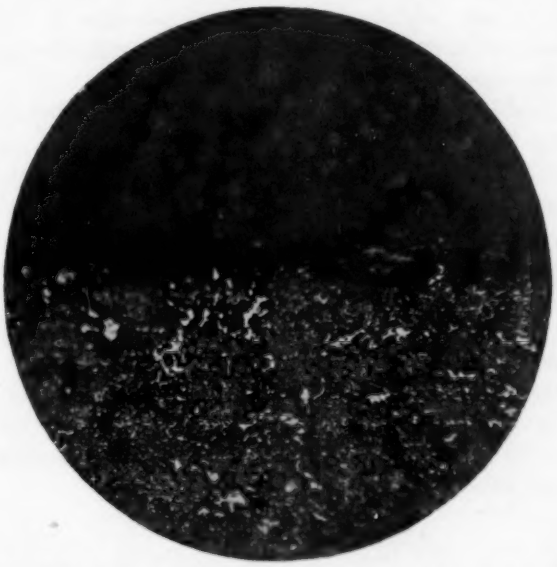

FIG. 7.—Etched, shows enamel vague grey, ground coat (black), cementite needles (white), pearlite (rough grey).

show round black patches resembling temper carbon. This arrangement of the carbon gives the sample a mottled appearance. Free cementite occurs in minute needles and narrow bands showing the honeycomb eutectic. The texture is very fine-grained, both cementite and pearlite. This sample had been taken from a tub which blistered badly, and also had a few black glass eyes, so called by the enameler.

This photograph resembles very closely Figs. 1 and 4.[1]

Fig. 7. This sample was taken from a perfect enameled tub. The sample has abundant graphitic crystals, most of which are arranged with

[1] Manson, *Jour. Amer. Ceram. Soc.*, **5** [11], 809 (1922).

flat face parallel to the enameled side. Free cementite occurs sparingly and is more abundant toward the enameled side. Texture of the pearlite is coarser than Fig. 6 and about the same coarseness as Fig. 3.

There is no weakness visible between the enamel and ground coat or between the ground coat and iron. This sample is a very good enameling iron.

Summary

Carbon has an intimate connection with the cause of blistering, lifting and in some cases with chipping. This is demonstrated by the chemical analyses as well as by the microphotos.

It is clearly shown that a low combined carbon and an evenly distributed graphitic carbon in very minute state will show no signs of blistering.

It seems that as soon as the combined carbon is high and if temper carbon is present the blistering of the enamel is certain.

The writer is unable to account for the increase of the carbon in the iron due to enameling heat treatment.

The changes in the combined carbon (in the pearlite) during the enameling process mean quite a radical difference in structural composition of the castings, the consequences of which the enamel must bear.

It is necessary to secure as nearly as possible uniform pig and scrap iron, and good quality of a dense and strong structure coke. All finished castings must have a uniform thickness, otherwise chipping, lifting, crazing also pinholes are certain.

The writer wishes to express his thanks to G. B. Schneider, General Manager, for his valuable suggestions and his hearty coöperation, also to C. E. Graham for his assistance in making the analyses and duplicates.

WASHINGTON IRON WORKS
LOS ANGELES CALIF.

CERAMIC ABSTRACTS

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the editor of *Chemical Abstracts* by coöperative agreement.

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Abrasives

Abrasive efficiency shown by tests. Lloyd Hatch. *Abrasive Indus.*, **5** [6], 140 (1924).—Methods pursued in the manuf. and testing of aluminum-oxide coated cloth are described. Special attention is given the effect of flexibility of the sheets on cutting value. Diagrams are shown which indicate that up to a certain point the cutting power increased with the flexibility. The data for the diagrams were obtained from readings on a mach. having a constant length of stroke combined with the constant press. of a block on a steel panel, the loss of wt. of which was detd. after each 50 strokes. The problem of wear resist. was also studied at the same time. P. D. H.

Corundum manufacturing data given. Anon. *Abrasive Indus.*, **5** [6], 157 (1924).—In the refining of natural corundum in an elec. fur. in an exptl. way, it is suggested that a copy of German patent specif. No. 85,021, issued Nov. 20, 1894 to Franz Hasslacher, Frankfort-on-Main, Germany, be obtained from the U. S. Patent Office, Washington, D. C. P. D. H.

Natural and artificial abrasives and their use in industry. B. Kleinschmidt. *Apparatebau*, **36,** 175–9(1924).—Descriptive, with 8 cuts of carborundum furnaces and app. for making grinding wheels. J. M. H. (*C. A.*)

Abrasives. Anon. *Mineral Ind.*, **32,** 1–6(1923).—A review of the industry of abrasives, natural and manufd. A. B. (*C. A.*)

Cement, Lime and Plaster

Ferrites of calcium and barium. E. Martin. *Chim. et Ind.*, 406–7(1924); *Jour. Soc. Chem. Ind.*, **43,** B867(1924).—On htg. the mixt. Fe_2O_3-$CaCO_3$ to a temp. not exceeding 1200°, monocalcium ferrite is formed: Fe_2O_3, CaO. It has a density of 4, is magnetic and non-hydraulic, and is insol. in 10% acetic acid and in sodium carbonate and ammonium chloride solns. Excess of alumina decomposes it at 1200°, while with silica silico-ferrites are formed having properties neither of the ferrite nor of calcium silicate. The dicalcium ferrite Fe_2O_3, 2CaO is formed by htg. the mixt. $Fe_2O_3 + 2CaCO_3$. It is attacked slowly by 10% acetic acid, is slightly sol. in boiling sodium carbonate soln. and entirely decomposed by hot ammonium chloride soln. If htg. of the above mixts. be carried to fusion the products differ in their chem. properties from the preceding ferrites. The product from the mono-mixt. has a density below 4, is magnetic, but is attacked slightly by water and 10% acetic dissolves out much lime. Barium compds. were studied because they are more easily prepared, BaO being more readily sol. than CaO. H. H. S.

Dehydration and re-hydration of gypsum. G. Linck and H. Jung. *Z. anorg. Chem.*, **137,** 407–17(1924); *Jour. Soc. Chem. Ind.*, **43,** B870(1924).—Gypsum is converted at 99° into the hemihydrate which at 195° loses water and becomes "sol. anhydrite."

This subs. absorbs moisture from the air to reform the hemihydrate, a reversible reaction unaccompanied by any change in cryst. structure. In further testing, "sol. anhydrite" undergoes sudden transformation into anhydrite identical with the mineral. Above 1000° $CaSO_4$ dissociates liberating SO_3; the resulting mixt. of CaO and $CaSO_4$ forms flooring plaster. The setting of plaster of Paris consists first of the rehydration of "sol anhydrite" to hemihydrate, then the soln. of this compd. in water and, finally, crystn. of the dihydrate. H. H. S.

Note on "gas concrete." ANON. *Tegel* (Stockholm), **13,** 91(1923).—A new highly porous building mat. invented by Axel Eriksson has been awarded the gold medal of the Swedish Academy of Engineering Science. It is a mixt. of Port. cement, burnt shale, and lime to which is added a catalyser. The H_2O of the mixt. becomes decomposed, the gas formed producing the porosity. The mat. attains a pumice-like structure; it has an excellent heat insulation; sp. gr. 0.7. A wall 20 cm. thick is said to give sufficient insulation for the climate of Sweden. Load carrying capacity and crushing strength, although low, are claimed to be high enough to permit the use of the mat. in small bldgs. without reinforcements. The mixt. of lime and burnt shale applied is considerably cheaper than Port. cement. The shale may be a combustible "alum shale" of which thick layers are found in S. Sweden. Factories for the production of the new mat. have been started; the mat. is being used in one of the largest new buildings, a sky scraper, in Stockholm. O. A.

Addition of fluorspar to cement-mix. H. KÜHL. *Zement,* **13,** 3–5, 9–10, 18–20 (1924).—K. investigated the effect of fluorspar on 2 cements—one highly siliceous and the other highly aluminous; the fluorspar contained 88% of CaF_2. The temp. at which an appreciable amt. of shrinkage occurred in the cement mixt. was measured, this shrinkage being regarded as showing the lowest temp. at which sintering took place with reasonable rapidity. Nacken had previously found that with normal cements it occurs at about 1270°. With both kinds of cement, noticeable shrinkage occurred at 870–910° with 5% of fluorspar, a larger proportion having no further action. With less than 5% the effect on the shrinkage temp. was greater with a siliceous cement than with an aluminous one, but the difference was not of practical importance. On overheating the shrunk material, much blistering and swelling occurred. The aluminous cement-mix when heated with fluorspar did not disintegrate except when the burning temp. was about 1150–1250° and very large proportions were used. The siliceous cement-mix with 5% of fluorspar produced a dense and stable clinker at 850–1150°; when heated to 1350° and cooled, it disintegrated, but after firing at 1430° it did not disintegrate. Mixts. contg. larger proportions of fluorspar behaved similarly, though at different temps. It is suggested that between 1100° and 1300° dicalcium silicate is formed and is the material which disintegrates, whereas at higher temps. the stable tricalcium silicate is formed. The cause of the discoloration of mixts. contg. fluorspar is not known; the discoloration occurs only when they are heated slowly; with rapid heating, such as occurs in com. firing, the discoloration is not produced. Under normal conditions of burning, no loss of F occurs, but when a temp. of 1600° is reached the clinker is devoid of F. The siliceous cement contg. fluorspar set unusually slowly, but the corresponding aluminous cement set very rapidly. Cements which, when rapidly fired, would not stand the boiling test showed no signs of cracking when 5% of fluorspar was added to the mix prior to burning. The addn. of fluorspar has no effect on the strength of the cement at 28 days. The addn. of 5–10% of fluorspar thus reduces the temp. required to form cement clinker from 1270° to about 1100° without having any serious disadvantages, except that the cement sets more slowly. B. C. A. (*C. A.*)

The thermal phenomena which accompany the setting of plaster. L. CHASSEVENT. *Compt. rend.,* **179,** 44–6(1924).—A calorimetric study of the setting of plaster has been

made in order to differentiate between the different reactions which take place during this process. There have been studied: (1) the liberation of heat due to the hydration of $CaSO_4$ which had been dehydrated at different temps., from 200° to 500°, as a function of the weight of the material and of the time, (2) the liberation of heat due to the hydration of the semi-hydrate. The following values have been obtained: heat of transformation of $CaSO_4$ to $CaSO_4.{}^1/_2H_2O$ + 2770 cal.; heat of soln. of $CaSO_4.{}^1/_2H_2O$ at 19° 3400 cal.; heat of crystn. of $CaSO_4.2H_2O$ at 19° from 400 to 700 cal.

J. H. P. (*C. A.*)

Super-cements. Otto Graf. *Z. Ver. deut. Ing.*, **68**, 853–6(1924).—Port. cement and other higher-grade cements are compared from the standpoint of the construction engineer. In general the super-cements are preferred for their greater strength, early high strength, resistance to chem. action, and low shrinkage. They are less desirable for their low elasticity, dark shade and high cost. As to the effect of the water/cement ratio in the mix and also the time of set they are similar to Port. cement. Few new data are given. H. F. K. (*C. A.*)

Fused cement. Nitzsche. *Zement*, **13**, 136–7(1924).—The action of 7.5% $MgSO_4$ soln. on fused cement briquettes was very slight during a 12-month period. At 90 days tensile strength of 34.7 kg. per sq. cm. and crushing strength of 702 kg. per sq. cm. were attained. On longer immersions the former strength increased while the latter decreased slightly. The contraction of specimens of both neat fused cement and of 1:3 mixes with sand in a 2.4% $MgSO_4$ soln., allowance being made for intermittent immersions and drying periods, was the same as that of check pieces in tap water.

H. F. K. (*C. A.*)

Silicic acid in Portland cement. F. Hart. *Zement*, **13**, 78–9(1924); See *Ceram. Abs.*, **3** [11], 312.—Additional expts. confirm H.'s previous conclusions that orthosilicic acid occurs in Port. cement. A sample of cement which showed "dusting" revealed in the dehydration curve of its gel breaks at 35.69% and 31.27% H_2O, corresponding to orthosilicic acid and $2SiO_2.3H_2O$. The dehydration curves of gels of separates retained on and passing 5000 meshes per sq. cm. showed 1 break at 37.9% and 2 at 37.7% and 33.1% H_2O, resp. This supports the current opinion that a silicate low in CaO causes the "dusting" of cement. H. F. K. (*C. A.*)

The products of hydraulic hardening and the hypothesis of their formation. Hans Kühl. *Zement*, **13**, 362–4, 375–6(1924).—In addn. to the usual compds. K. finds $4CaO.Al_2O_3.nH_2O$ crystd. in minute octagons and also 4 $CaO.3SiO_2.nH_2O$. A difference in the products results from adding normal or excess amts. of water to cement. Any mixt. of active CaO, Al_2O_3 and SiO_2 will set, but the d. and especially the time of set will det. its fitness as a cement. K. holds that the greatest strength can only be obtained through the simultaneous formation of cryst. and gel hydration products. Compn. ranging from Portland to alumina cements can be used safely and made economically if sufficient CaF_2 (5–15%) is added to the clinker. H. F. K. (*C. A.*)

PATENTS

Process of making cement and by-products. Edwin C. Eckel. U. S. 1,511,323, Oct. 14, 1924. The process of making cement and iron, comprising fusing a mixture of lime and titaniferous iron ore in a furnace, tapping off the resulting iron, and cooling and grinding the remaining cement slag.

Enamels

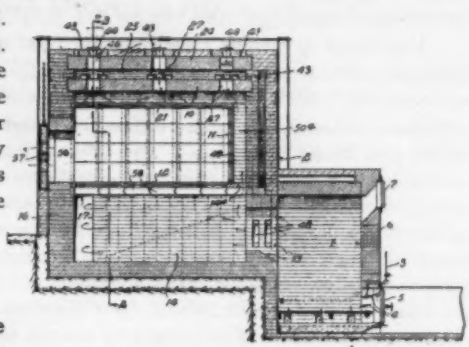
Testing enameled objects. Otto Rino Angelucci. *Giorn. chim. ind. applicata*, **6**, 167(1924).—Fill the enameled vessel to be tested with a soln. of an electrolyte or even with water. Connect the ends of the secondary of an induction coil so that one end is in contact with the metallic part of the vessel and the other end with the liquid

contained in it. When the primary circuit is closed sparks form between the end of the secondary immersed in the liquid and that part of the metal not covered with enamel, even if such surface is a fraction of a mm.[2] If there is no metal exposed the secondary circuit is interrupted and the current does not pass. R. S. P. (*C. A.*)

PATENTS

Enamel composition. HUGH S. COOPER. U. S. 1,510,829, Oct. 7, 1924. An enamel compn. adapted to produce a substantially white opaque coating on metals, said compn. contg. a cerium compd. and a compd. of another rare-earth element occurring in monazite sand as opacifying ingredients.

Enameling furnace. ALBERT F. H. SEELIG. U. S. 1,515,368, Nov. 11, 1924. In a fur. of the kind described, the combination of a htg. chamber, a muffle supported therein, and means for directing the hot gases in a plurality of passes and in opposite directions under and in direct contact with the bottom of the muffle.



Glass

The effect of composition on the viscosity of glass (Part II). S. ENGLISH. *Jour. Soc. Glass Tech.*, **8** [31], 205(1924).—An investigation on the viscosity of the same series of glasses that were used in Pt. I of this study. In the present investigation an entirely different type of app. is used, and the temp. is extended up to 1400°C. Viscosity detns. of the various glasses at progressively increasing temps. are tabulated and viscosity-temp. curves are presented. The simple two component glasses, from which all the glasses used in this investigation were derived by substitution were two sodium silicates, one having a molecular composition of: $6SiO_2,2Na_2O$; the other being: $4SiO_2,Na_2O$. In the case of the soda-lime-silica glasses, throughout the whole range of temp. from the annealing points of the glasses up to 1400° the molecular replacement of sodium oxide by calcium oxide in a sodium trisilicate until the basic and alkaline oxides are present in equimolecular propns. causes a continuous increase in the viscosity at any particular temp. Also the increase of temp. necessary to cause a reduction of the viscosity by one half increases very rapidly as the temp. is raised. The curves resulting from the study of the soda-magnesia-silica glasses show that throughout the whole range of temp. investigated the substitution of sodium oxide by magnesia in a sodium trisilicate causes a very marked increase in viscosity. Substituting sodium oxide in a sodium trisilicate by magnesia causes a distinct increase in the rate of setting over this particular range, but the effect is not nearly so great as in the case of the lime containing glasses. In the case of the soda-alumina-silica glasses the curves show that for equimolecular substitutions, alumina causes an increase of viscosity about 8 or 9 times as large as that caused by lime and about 4 times as large as that caused by magnesia. Alumina also reduces the rate of setting of the glass, and for this reason is beneficial in producing better working properties in glasses. In the substitution of boric oxide for silica, as the substitution proceeds the rate of setting of these glasses increases very rapidly. Also, the greater the proportion of boric oxide present the more pronounced is the reduction in viscosity. J. G. P.

Further investigations of the influence of alumina on the properties of glass. VIOLET DIMBLEBY AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **8** [31], 173(1924).—

Two series of soda-alumina-silica glasses were prepd., one contg. approx. 18%, the other 14.5% of soda, and amounts of alumina in substitution of the silica rising from 0 to 19.69% in the first and 0 to 15.50% in the second series. The properties of the resulting glasses with variable alumina contents were then made. Replacement of silica by alumina up to about 10% results in a slight rise in annealing temp.; beyond a substitution of 10% the rate of increase of annealing temp. is considerably greater. The substitution of silica by alumina is without appreciable effect on the linear coeff. of thermal expansion. Introduction of alumina instead of silica results in a steady increase in the density, the average increase for each per cent substitution being 0.00356 in the series containing about 18% of soda and 0.00407 in that contg. about 14.5%. J. G. P.

The decay of window glass from the point of view of lichenous growths. ETHEL MELLOR. *Jour. Soc. Glass Tech.*, **8** [31], 182(1924).—The botany and history of lichens as pertaining to their effect on window glass is taken up. J. G. P.

Some observations on the influence of titania on the properties of glass. A. R. SHEEN AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **8** [31], 187(1924).—A series of titania contg. glasses were prepd. of general compn. $6SiO_2,xNaO_2,yTiO_2$, where $x + y = 2$, and in which the percentage of titania reached 19.4. It is necessary to melt such glasses in a non-reducing atmosphere, otherwise colors are obtained ranging from light yellow, through amber, to dark brown. For this reason titania might be employed for producing yellow or amber colors in glass. No difficulty occurs in working glasses of the above type even with 10 to 15% of titanium oxide, but difficulties do occur above this concentration, the glass being very viscous and setting very rapidly. When titania replaces sodium oxide the resist. of the glass to the attack of boiling water increases rapidly and the glasses are almost as equally resistant as those contg. the same percentage wt. of magnesia. When the amt. of titania present is between 10 and 19.5% the resist. rises and becomes ultimately superior to several of the best commercial resistant glasses. Progressive introduction of titania into a glass of the type examined does not appear to improve the resistance to caustic alkali soln. until 10% is present, but at that and subsequent stages the improvement is marked. In this respect titania glasses are superior to high silica glasses. The annealing temp. of titania-contg. glasses increases rapidly with increase in titania content, the rate of increase being greater than for corresponding glasses containing lime, magnesia or alumina. Considerable reduction in the thermal expansion occurs on replacing sodium oxide by titania. The oxide is not so effective as magnesia in this respect, and is very distinctly inferior to silica and boric oxide. From our expt. it appears, however, to have a favorable influence on the thermal endurance. The refractive indices of titania glasses are higher than those of corresponding lime glasses. The total dispersion is considerably greater than exhibited by lime glasses, the total dispersion increasing slowly with concentration. The densities of the titania glasses have also been detd. Finally, over the range investigated, no evidence has been forthcoming of similarity of behavior between boric oxide and titania in giving maxima and minima on the curves showing the relationship between compn. and phys. properties. J. G. P.

Colored glasses. A. GRANGER. *Chim. et Ind.*, 408–10(1924); *Jour. Soc. Chem. Ind.*, **43**, B870(1924).—Colors may be due to chem. action or to colloidal distribution in a colorless glass. Cobalt is said to be the only stain which has a purely chem. action. The red, pink, brown, yellow, colors produced by gold, selenium, carbon, sulphur, etc., are colloidal. Copper red is said to be due to metallic copper and not to cuprous oxide. At high temps. the stable form is Cu_2O but on cooling it becomes CuO and Cu.

H. H. S.

Process for the elimination of iron from the raw materials of ceramic and glass products. ORAZIO REBUFFAT. *Atti congresso naz. chim. pura applicata*, **1923**, 282–3.—

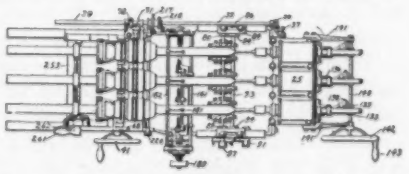
Unlike purely phys. methods (levigation, magnetic sepn., etc.) used in the past for removing Fe from raw materials of the glass and ceramic industries, a new method is described which depends on *chem. sepn.* Fe compds. in clay, kaolin and sand which cannot be removed physically can often be completely dissolved out by HCl, but in other clays this treatment is unsuccessful. On the other hand the Fe in kaolin, clay, bauxite, siliceous sand and feldspathic silica can be completely and easily removed by *treatment with* $H_2S_2O_4$. The reaction is rapid and quant., only the theoretical amt. of acid based on the Fe being required. The sol. Fe^{++} salt is removed by filtration or by decantation in the presence of dil. H_2SO_3 to prevent repptn. of a basic Fe salt. Grades of kaolin and sand hitherto useless for glass and ceramics can be rendered suitable for white products. C. C. D. (*C. A.*)

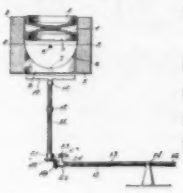
The electromotive properties of glasses. HANS SCHILLER. *Ann. Physik*, **74**, 105–35(1924).—Samples of 5 different kinds of glass were tested. Each sample was in the form of a small tube with a spherical bulb blown at one end. The tube was filled with a soln., such as NaCl, and suspended so that the bulb was immersed in a beaker filled with the soln. The elec. connections were arranged so as to avoid various errors which have occurred in previous investigations. The results showed that the application of high field strengths (100 or more v.) produced counter e. m. f.s in the glass of the same order of magnitude as the applied potential difference. The results are correlated with those of Horovitz (*C. A.*, **18**, 193). The possibility of characterizing any variety of glass by finding its "solution pressure" is discussed. W. W. S. (*C. A.*)

The cause of the color produced in glasses of anhydrous borax and sodium metaphosphate by fusion with metallic oxides. THEODORE COHN. *Chem. News*, **129**, 32–5 (1924).—Oxides of different metals were added to microcosmic salt or borax and fused in a loop of Pt wire. Observation of color was made in daylight against a glazed white tile. The salts of Au, Ag and Pt impart a color which is due to colloidal free metal, and which varies with the concn. of metal and heat treatment. The colloidal metal may be pptd. by suitable reagents. With Co, Ni and Cu the color is due to the formation of metallic metaborates and pyrophosphates. No orthophosphates are formed as long as the beads are transparent. Colorless beads of Na metaphosphate contg. colorless cuprous phosphate in solid soln. are decompd. by H_2O to form cupric phosphate and metallic Cu. M. O. L. (*C. A.*)

PATENTS

Multiple glass-blowing machine. ALEXANDER KANN. U. S. 1,511,889, Oct. 14, 1924. In a device of the class described, the combination of means for gripping a plurality of glass tubes at their opposite ends, means for rotating said gripping means, heating means intermediate the ends of said tubes, and means associated with said gripping means for uniformly forcing the same amount of air into each of the tubes. In a device of the class described, the combination of means for gripping and rotating a glass tube, burners for heating said tube, brackets in which said burners are rotatably mounted, a shaft upon which said brackets are mounted, manipulative means for moving said shaft vertically.



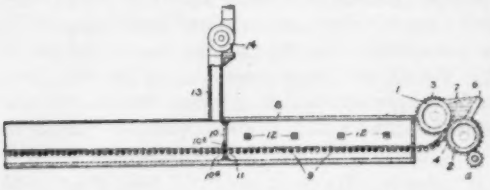


Cleaner for glass pots. WILLIAM WESTBURY. U. S. 1,511,550, Oct. 14, 1924. In combination with a melting kiln, and a pot adapted to be disposed in inverted position therein, a scraper for removing glass from the inverted pot within the kiln, and means for actuating said scraper.

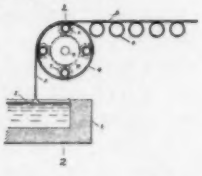
Glass. FRED M. LOCKE. U. S. 1,510,521, Oct. 7, 1924. A

glass contg. over 78% of silica, under 5% of alkali, alumina, an alkali earth, and boric oxide, and having a coeff. of expansion substantially .0000032.

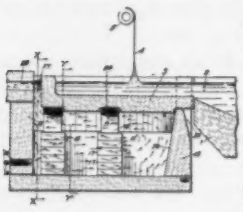
Process and apparatus for forming and annealing sheet glass. FREDERICK GELSTHARP. U. S. 1,513,544, Oct. 28, 1924. In combination with means for forming and feeding ahead a ribbon of plastic glass, of a leer in line therewith provided with rollers for advancing the ribbon therethrough, baffle means extending from the upper side of the glass to the ceiling of the leer and from the lower side of the glass to the floor of the leer for dividing the leer into an annealing end and a cooling end, and means to cause the rapid cooling of the ribbon during its last period of travel through the leer.



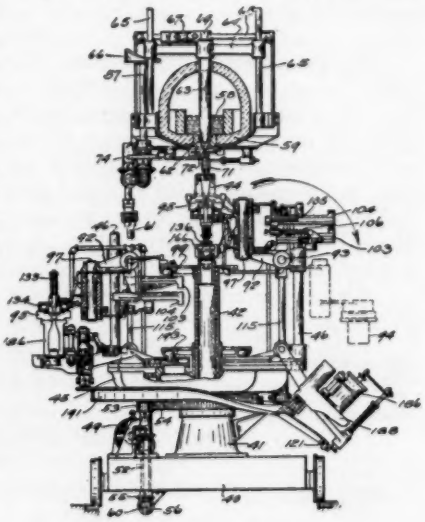
Apparatus for making continuous sheet glass. JOSEPH P. CROWLEY. U. S. 1,514,953, Nov. 11, 1924. In an app. for drawing continuous sheet glass, a bending device for the sheet, comprising a rotatable drum, and roller supporting means for the drum through which means the drum is frictionally driven.



Sheet-glass-drawing furnace. ENOCH T. FERNGREN. U. S. 1,515,021, Nov. 11, 1924. In a sheet glass drawing mach., the combination with the draw-pot contg. the molten glass from which the sheet is drawn, and the heating chamber beneath the pot, of a supporting stool for the pot located in the htg. chamber, comprising a series of open arches, each alternate arch being inverted and each adjoining pair of arches having one limb in common, the pot resting on the crowns of the upright arches, and a series of piers on which the crowns of the inverted arches are supported, the bottom of the pot being cut away where it rests upon the stool, to provide a more uniform thickness of mat. between the molten glass and the htg. means in the chamber.

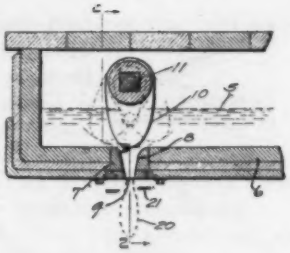


Glass-forming machine. LEONARD D. SOUBIER. U. S. 1,512,372, Oct. 21, 1924. In a glass forming machine, the combination of a rotating carriage, blank molds, inverting heads by which the blank molds are carried, said heads connected to rotate with the carriage, means to swing said heads about horizontal axes for inverting the blank molds and bringing them to a charge receiving position at the center of the machine, finishing molds, supporting devices therefore connected to rotate with the carriage, and a track on which said devices run, said track formed to lower the finishing molds into position to clear the blank molds and their inverting heads and to move the finishing molds upward into position to receive the blanks when the blank molds are opened.

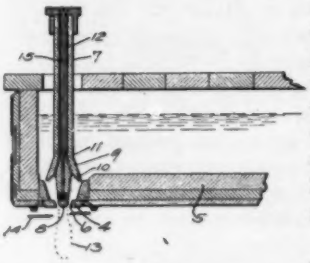


Glass feeder. LEONARD D. SOUBIER.

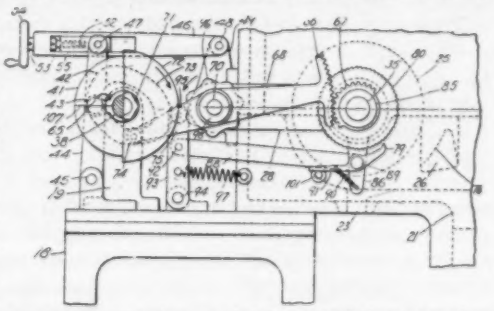
U. S. 1,512,373, Oct. 21, 1924. A container for molten glass having a discharge opening extending through the floor thereof, a regulator to control the discharge of glass, said regulator comprising a body of refractory material extending downwardly in the glass above the opening, and means to oscillate said body about a horizontal axis and thereby swing the lower end thereof to and from a position directly over and adjacent to the outlet.



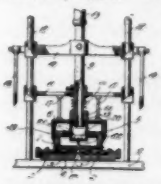
Glass feeder. LEONARD D. SOUBIER. U. S. 1,512,374, Oct. 21, 1924. The combination of a container for molten glass having an outlet orifice in the bottom thereof, the walls of the orifice consisting of material to which the glass will not adhere, and means to control the discharge of glass through the outlet comprising a body projecting into the glass, and consisting of material to which the glass will not adhere, said body having a tip formed of refractory material to which the molten glass adheres.



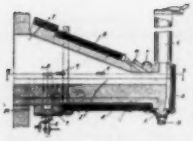
Apparatus for separating molten glass into mold charges. WILLIAM A. LORENZ. U. S. 1,514,059, Nov. 4, 1924. App. for segregating molten glass into mold charges, comprising a container having a submerged outlet, a drive shaft, a driven shaft connected with the drive shaft, a sleeve surrounding said driven shaft, a rocking device pivoted upon said sleeve, an impeller rotatably mounted on said rocking device adjacent to the outlet, means on said drive shaft for oscillating said rocking device to move the impeller toward and from the outlet, a pawl and ratchet mechanism for advancing the impeller step by step about its axis of rotation, a second rocking device for actuating said pawl and ratchet mechanism, and a member mounted on said driven shaft for actuating said second rocking device.



Glass blowing and trimming machine. RAYMOND F. HANCOCK. U. S. 1,513,756, Nov. 4, 1924. A machine of the class described comprising a die for supporting a pliable sheet, a blow-head for application to the sheet to force it into conformity with the die, and an edge trimmer for the sheet surrounding said blow-head. In a machine of the class described, the combination of a die for supporting a pliable sheet, and a blow-head for application to the sheet to force it into conformity with the die, said blow-head being provided with a fluid pressure supply, a recess opposite a portion of said sheet and said die, and orifices leading from said fluid pressure supply to said recess, said orifices discharging toward a wall of said blow-head.

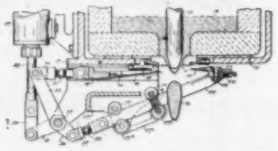


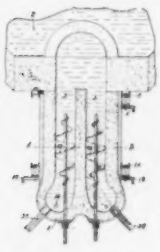
Method and apparatus for delivering viscous glass. OLIVER M. TUCKER AND WILLIAM A. REEVES. U. S. 1,512,566, Oct. 21, 1924. A spout for delivering viscous glass from a furnace comprising a body portion with a delivery aperture therein, and ports for the introduction of a temperature controlling medium, said ports being directed



both inwardly toward the furnace, and outwardly toward the outer end of said spout. In spout structure for delivering viscous glass, a glass trough, a U-shaped channel member for the reception of a temperature modifying medium, the vertical legs of said U-shaped channel member extending upwardly through the vertical side walls of said spout and passing through the sides of the spout above the glass line for the delivery of said medium into the spout above the glass.

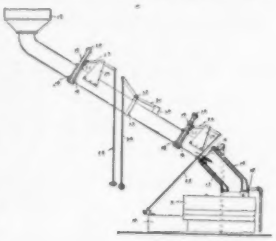
Glass-cutting apparatus. ENOCH T. FERNGREN. U. S. 1,512,412, Oct. 21, 1924. In glass feeding app., the combination of a container for molten glass having an outlet opening in the bottom thereof, cutters arranged beneath and at opposite sides of said opening, one of said cutters mounted to reciprocate horizontally, and consisting of a flat blade having a V-shaped notch forming a cutting edge, said blade being forwardly and upwardly inclined, a carrier for the other blade mounted to reciprocate in an inclined direction by which it is moved downward as it advances, and means to actuate said blades and cause the first mentioned blade to advance more rapidly than the second blade, the downward inclination of the direction of movement of the second blade being greater than the inclination of the first mentioned blade to compensate for the relatively rapid movement of the first mentioned blade.





Automatic glass-feeding machine. THOMAS WILLIAM WARREN. U. S. 1,512,383, Oct. 21, 1924. In a glass feeding device the combination of an extension adapted to align with an aperture in the wall of a glass tank, a body portion thereto, two enclosed channels with semi-circular bottoms, a screw conveyor in each channel, two chambers with raised floors opening therefrom, with controlled outlets from each chamber.

Feeding device for glass furnaces. FORREST L. HITCHCOCK. U. S. 1,512,223, Oct. 21, 1924. A feeding device for glass furnaces and the like having a permanent opening therein, comprising a feed pipe extending downwardly in position to be at all times in constant communication with said opening, means for supplying material to said pipe for discharging into said furnace, a sliding gate valve mounted on said pipe so as to extend therein and close the same, a bell crank lever pivotally mounted on said pipe, a link connecting said bell crank lever and said gate valve, and means connected with said bell crank lever and extending to within reach of the operator for permitting the same to be operated so as to open and close said valve.

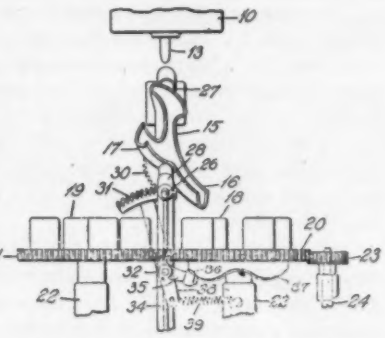


Glass-rolling pallet. HARRY F. ANDERSON. U. S. 1,513,731, Nov. 4, 1924. A pallet upon which glass is rolled into sheet form, having a portion of its surface provided with an anchoring field to which the glass will cling when pressed into engagement therewith during the rolling operation, whereby to prevent the glass from creeping along the pallet during the rolling operation.

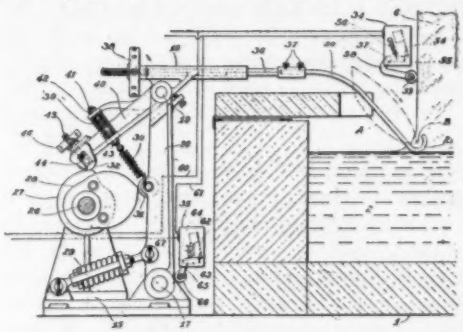
Process for producing glass forms. OSCAR A. BOEHM. U. S. 1,512,013, Oct. 21, 1924. The process of producing glass forms having a bore which comprises heating a portion of a glass form having a bore open at one end and closed at the other thereby causing a contraction of the bore in the vicinity of the heating, causing a forming plunger to have a reciprocating

movement within the bore during the heating operation and forming an opening in the closed end of the form.

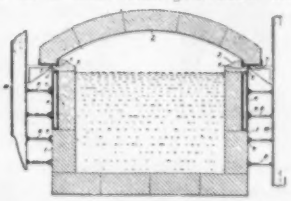
Glass-delivering apparatus. WILLIAM H. HONISS. U. S. 1,514,526, Nov. 4, 1924. App. for handling molten glass, comprising a feeder, a Y-shaped delivery trough mounted to receive the glass on the stem of the Y and having its fork inclined downwardly, a pivotal mounting for the trough having its axis approximately coincident with the receiving portion of the trough, molds, means for positioning the molds alternately on each side of said axis, and means for rocking the trough on its axis to lower the forks alternately in time with the positioning of the molds.



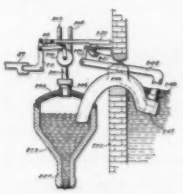
Edge-holding device for sheet glass. JOSEPH H. REDSHAW. U. S. 1,514,338, Nov. 4, 1924. The combination with apparatus for drawing a sheet of glass from a molten bath, of means for preventing the inward movement of the edge of the sheet comprising a pair of fingers spaced apart to receive the edge of the sheet, and driving means including an electric motor for moving the fingers at intervals downward into the glass bath and outward, a device comprising a member yieldingly pressed against the edge of the sheet and a switch operable therefrom for governing the supply of current to said motor so that the motor is stopped when the edge moves out beyond a predetermined point, and is started when it moves in beyond a predetd. point, and means for preventing the stopping of the motor until said fingers are withdrawn from the glass bath.



Water-cooled glass-tank furnace. ARNO SHUMAN. U. S. 1,514,307, Nov. 4, 1924. In a water-cooled glass-tank furnace the combination of a side wall provided at its top with an external cavity, a water-cooled box arranged in the cavity and having its top flush with the top of the side wall, a roof spaced from the side wall, and a stone as 3 extending from the inner face of the tank between the top of the box and roof and stopping the space, substantially as described.



Method and apparatus for flowing molten glass. CLYDE R. LOTT. U. S. 1,514,091, Nov. 4, 1924. The combination of a tank to contain molten glass, a stationary charging receptacle arranged to the side of and whereby to receive the glass from the tank, the tank having an outlet in its side at a point above the normal level of the glass in the tank, means for controlling the discharge of glass from the charging receptacle, means for controlling the discharge of glass from the tank through its outlet into the charging receptacle, common actuating means for both of said first-mentioned means whereby they operate in

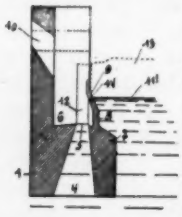


synchronism and at stated intervals, and shears periodically operating to sever the glass discharged from the charging receptacle.

Alumina and other compounds for glass manufacture. R. L. FRINK. Brit. 215,810, Jan. 15, 1923. Kaolin, clay, shale, coal refuse, feldspar or other Al-silicate-contg. material is heated to a reacting temp. with an alkali chloride and an alk. earth by means of glass-furnace gases or other gases contg. H_2O vapor and C and S oxides. The reaction products are leached with H_2O and the insol. residue, which may be Ca silicate or a Ca Al alkali silicate, may be used for the manuf. of glass. The soln. is treated with the heating gases which produce pptd. alumina. The remaining soln. comprises carbonate and sulfate, which may be used together in glass making or may be sepd. An app. is described. (*C. A.*)

Desilvering fragments of silver mirrors. A. STERNBERG. Ger. 391,131, Feb. 26, 1924. Fragments of mirrors (silvered by reduction of silver soln.) cannot be used up in glass works owing to their silver content. On the other hand the silver content is so small that a regeneration by dissolution would be too expensive. Fragments of mirror are treated with dil. H_2SO_4 or with $NaHSO_4$ soln. for several hrs., the liquid is decanted and the fragments are dried in the open air at 120°. Care must be taken that the temp. does not rise to 180° or higher, because in that case the Ag is converted to sulfate. By agitating the dried fragments in water, the silver particles are sepd. and can be filtered off. To produce Ag salts the fragments are placed in an earthenware pot having a double bottom and the space below the perforated false bottom is filled with dil. HNO_3. The pots are placed in a chamber heated to 120–130°, and the vapors from the boiling acid convert the Ag to nitrate. (*C. A.*)

Means for the manufacture of glass in continuous sheets. EUGENE ROWART. U. S. 1,515,174, Nov. 11, 1924. The process of drawing a glass sheet from a mass of molten glass, the said process consisting in lifting vertically first from the said mass two narrow strips of glass from a point below the level of the mass of molten glass, the said strips being lifted at a distance from each other corresponding to the width of the glass sheet which is to be produced, then lifting the sheet of glass from the mass of molten glass between the said strips, whereby the said strips become united with the glass sheet and finally lifting simultaneously the sheet and strips. In app. for the drawing of glass in continuous sheets, the combination with a glass container, of two refractory pieces arranged at a distance from each other corresponding to the width of a sheet of glass which is to be produced, a hollow space in each of the said pieces, the said hollow space being open in one face of the piece, a passage in the bottom of each piece, the said passage ending by a drawing hole in the said bottom, a lip in the front face of each piece, the said lip being inclined and gradually thinner towards the hollow space and provided with a groove, the bottom of which is at a level above the bottom of the hollow space of the piece, means for immersing the said pieces into a mass on molten glass in the container, whereby two narrow strips of glass may be lifted from the bottom of the hollow space of the refractory pieces before the molten glass in the container has reached the bottom of the groove in the inclined lip, the said strips uniting with the sheet of glass lifted from the mass of molten glass, between the said inclined lips.



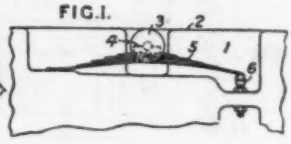
Method and apparatus for the manufacture of glass plates. FRANK L. O. WADSWORTH. U. S. 1,515,450, Nov. 11, 1924. In app. of the class described the combination of a Janus faced table, means for depositing masses of molten glass at either end of said table, means for rolling out said masses to sheet form in alternately reversed direction thereon, means for reversing the table between successive rolling operations so as to reciprocally expose the opposite faces thereof to the heating effects of the molten glass,

means for symmetrically cooling said faces by currents of cooling fluid flowing in the direction in which the last formed sheet was spread, means for pressing the successive sheets while they are supported on the alternately presented table surfaces and means of transferring the pressed plates from the said supporting surfaces to a plurality of leers each of which comprises a connected series of annealing chambers.

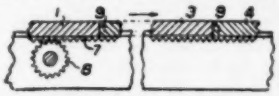
Grinding glass. PILKINGTON BROS., LTD., GLASS WORKS AND F. B. WALDRON. Brit. 25900/22. In a machine for the continuous grinding of glass plates, in which a series of tables carrying the glass pass under the grinding-runners, the sliding friction between the tables and the guides is in part replaced by rolling friction. The tables slide on guide-surfaces 2, and the rolling-friction devices, which are located at intervals along the machine, each comprise a wheel or roller 3, which may be double as shown in Fig. 2, supported in a bearing 4 fixed to a spring 5. The spring rests at one end thereof on the machine frame 1, and at the other end is pivoted to a bolt 6, the upward pressure of the wheel upon the table being varied by adjustment of the bolt. Counterweights may be employed in place of the springs, or wheels may be mounted in spring-supported journals on the table, and run on tracks adjacent to the guides. The upward pressure of the wheels on the tables may be adjusted so as to be a maximum at the starting end of the machine, whereby the pressure between the tables is more nearly equal throughout the machine.

FIG.2.

FIG.1.

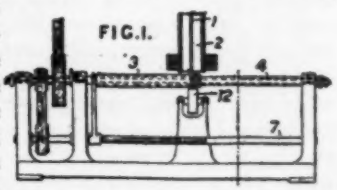


Grinding and polishing glass. PILKINGTON BROS., LTD., GLASS WORKS AND F. B. WALDRON. Brit. 26526/22. In apparatus for the continuous grinding and polishing of plates of glass, in which the plates are mounted on a series of tables moving continuously under grinding and polishing discs, the tables being removed after passing the last disc, and a new table added to the series, the tables are frictionally registered to prevent relative movement therebetween and the consequent breakage of the plates which overlap the juncture between two tables. The frictional registering is obtained by moving the tables by a drive applied to the last one added only and communicated from one table to the next through the abutting ends; thus tables 3, 4 are the first in the series, and table 1 is the last one added, the drive, which is through a pinion 8 and rack 7, being applied to table 1 only. The pressure between the abutting ends of the tables is sufficient to prevent relative movement. The friction between the tables may be increased to allow for the different grinding pressures at different sets of grinders, by shaping the ends of the tables to give greater intensity of pressure. Registering devices 9 may be provided. P. D. H.

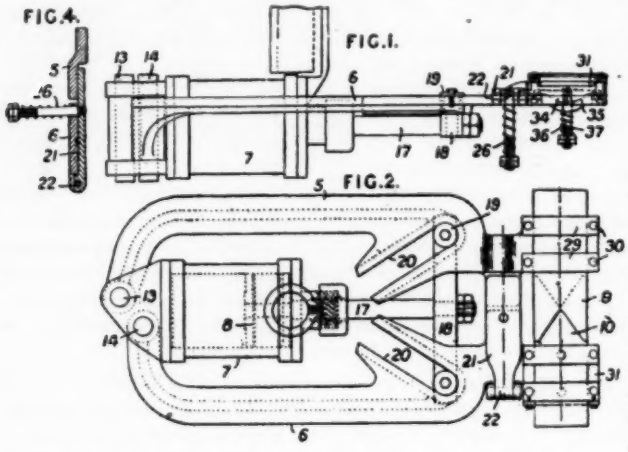


Forming silica glass articles. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 22934/23. Relates to the production of tubes from fused quartz and consists in winding cane or strip quartz while plastic upon a mandrel, so that adjacent coils are in close proximity, and subjecting the coils, while still plastic, to pressure on the mandrel to cause them to coalesce. The strip or cane 1 of quartz glass is passed through a tubular electric heater 2, and is wound on a carbon mandrel 3 which is mounted on a rotatable shaft 4. The mandrel is fed forward by a loading-screw 7 so that the cane coils uniformly on the mandrel. The shaft 4 may be electrically heated, and a flame from a blowpipe may be directed on to the cane as it coils on the mandrel. A roller 12 presses against the plastic quartz helix and causes the coils to coalesce and form a tube.

FIG.1.



Glass manufacture. RYLETT'S LONDON SECRETARIAT (SERVICES), LTD. AND A. MCNISH. Brit. 28492/22 (*Pott. Gaz. and Glass Trade Rev.*, April, 1, 1924). A device for shearing a gob or gather of glass from the metal delivered from a furnace comprises a pair of mechanically operated tongs carrying the shear blades, and means adapted to maintain blades in resilient contact with one another and to have a substantially parallel shearing movement. The device consists of a pair of tongs 5, 6 pivoted to the back end of a cylinder 7, containing a piston 8, the shear blades 9, 10 being clamped to the front ends of the tongs. The tongs are mounted on separate pivots 13, 14 which are arranged adjacent to one another, and the radius of movement of the blades is such that they come together with a substantially parallel movement. The piston rod 17 is provided with a crosshead 18 having rollers 19 which work in inclined slots 20 on the tongs, so that the stroke of the piston opens and closes the tongs. In order to cause the blades to maintain their plane of action, during shearing, a metal tongue or plate 21 is pivoted to the tong 6 at 22 and held against it by a spring 26. This plate lies in contact with both tongs, as shown in Fig. 4, and prevents them from getting out of alignment with one another should the blade 9 tend to rise. The blades are adjustably clamped to the tongs by means of bars 29 and bolts 30. The blade 10 may be mounted in a saddle 31 provided with a curved part 34, Fig. 1, which seats in a seating 35 on the end of the tong. The saddle is resiliently held in place by springs 37 and bolts 36, so that slight rocking of the saddle is permitted and the blades are held resiliently in contact. In a modification the crosshead 18 is replaced by a plate with inclined slots that engage rollers on the tongs.



P. D. H.

Heavy Clay Products

Load tests of brick pillars. R. R. SCHLYTER. *Tegel* (Stockholm), **13,** 64(1923).—The testing included 2 pillars of ordinary brick in a hollow wall of system "Ottermur," cross-section 80 x 23 cm., height 280 cm., and 3 pillars of concrete and slag concrete, system "Arco," cross-section 120 x 30 cm., height 300 cm. In one test of each kind the load was unsymmetrically applied, the load center being placed 4 cm. away from the center of the cross-section in the direction of the shorter side of the section. In the other tests the load was symmetrically applied. The symmetrically loaded pillars of "Ottermur," tested at an age of 7 months, would yield at a load of 49 kg./sq. cm., figured on the entire cross-section, 62 kg./sq. cm. figured on the effective surface (cross-section minus hollows), 113 metric tons per running m. of wall, 23 cm. thick. The eccentrically loaded pillar yielded at 25 kg./sq. cm. (entire cross-section), 32 kg./sq. cm. (effective surface), 58 tons per running m. The crushing strength of the brick averaged 309 kg./sq. cm., that of the mortar at 28 days' age 5 kg./sq. cm. and at 7 months' age 8 kg./

sq. cm. The pillars of the "Arco" system were tested one month old. The symmetrically loaded pillar built of massive concrete brick in a hollow wall yielded at a load of 41 kg./sq. cm. (entire cross-section), 68 kg./sq. cm. (effective surface), 120 tons per running m. of wall, 30 cm. thick. Expts. were made with a new method for detn. of the crushing strength of brick. 20 half brick were made into 10 cubes by joining two different halves; on these ordinary detns. of crushing strength were made. From the other 20 halves cylindrical cones, 5 cm. in diameter and 5 cm. high, were drilled leaving out the marginal parts of the brick. The results were the following:

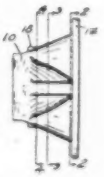
	Crushing strength, kg./sq. cm.	Per cent
Av. of 10 cubes	309	100
Av. of weakest cylinder of each cube	319	103
Av. of strongest cylinder of each cube	471	152
Av. of all 20 cylinders	394	128

O. A.

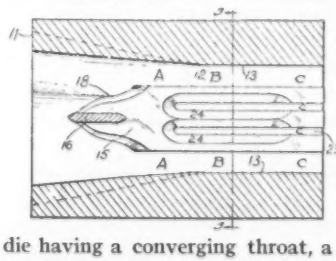
$10,000 well spent saves many thousands yearly. DEAN W. TAYLOR. *Brick & Clay Rec.*, **65** [1], 31(1924).—The kilns which are down-draft have been equipped for forced draft firing. The air which is furnished by individual blowers at each kiln, driven by $1^1/_2$ h. p. motors, is delivered to the 10 fireboxes by means of a 12 in. duct encircling the kiln, with 4 in. branches at each firebox. Air under a uniform press. is thus delivered to all parts of the kiln with the foll. advantages: Better control during water-smoking positive circulation in the kiln prevents condensation and its resulting scum; better control during the firing and finishing period; and a reduction of more than 3 days in the firing time. Waste ht. from the kilns was being used for drying and the old installations included four 20 ft. mine fans driven by steam engines. It was found that these fans required $14^1/_2$ T. of coal per 24 hrs. to oper. Two of the fans at the receiving end of the drier were replaced with a stack and the other 2 were replaced with a 6 ft. multi-blade fan driven by a 40 h. p. motor with a saving of several thousand dollars a year. P. D. H.

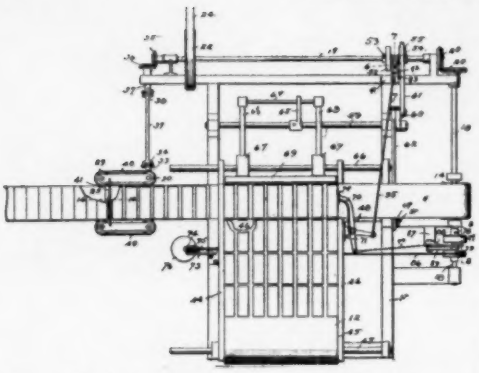
PATENTS

Die for forming hollow blocks. GEORGE W. DENISON. U. S. 1,513,589, Oct. 28, 1924. In a device of the class described, a die having an enlarged receiving end restricted on two sides, and an extruding end substantially rectangular in cross-section, and having cutting means on the receiving end of the die adapted to direct material into the enlarged portions on the sides of the restricted part.



Method of and apparatus for making hollow brick. LEONARD A. DENISON. U. S. 1,513,590, Oct. 28, 1924. The method of forming hollow brick which includes the steps of first forming a hollow column having a webbed cross-section, with intermediate parallel webs extending between two opposite walls of the column, further extruding the column to decrease the thickness of the outer column walls, causing the excess mat. to form bulging masses on said webs and finally forming the bulging masses into transverse webs connecting the first formed webs to each other and to end walls of the column, said steps being effected as the column is continuously extruded. The combination of a die having a converging throat, a core comprising a bridge mounted in the throat of the die and column void forming members mounted on the bridge, said members having cavities formed therein intermediate the core bridge and the die mouth.





Device for handling plastic brick. HALVER R. STRAIGHT. U. S. 1,510,717, Oct. 7, 1924. The combination of a cutter table having a continuously moving column of adjacent plastic brick, a receiving conveyor, arranged longitudinally with said column, means for driving said receiving conveyor at a speed slightly above that of said column, a conveyor at each side of said column, designed to engage the sides of said brick at a point just ahead of the delivery end of said table, and means for driving said side conveyors at a speed equal to that of the receiving conveyor.

Refractories

On the addition of chromium oxide to silica bricks. STEN SANDLUND. *Jernkontorets annaler* (Sweden), 45–52(1923).—S. has tested a method suggested by Dornhecker (*Stahl u. Eisen*, 1920) for increasing the resist. of silica brick to the corrosive action of FeO bearing slags by adding Cr_2O_3 to the brick. A protecting layer of the highly refrac. chromium spinel, $FeO.Cr_2O_3$, is supposed to be formed at the contact between the brick and the slag. S. produced some hand made silica pots, fired at 1450° C, of the compns. A, B, and C. In these he melted slags of compositions I, II, III, and IV at temps. 1550–1600° C. Charges of 10 g. were used. The m. p. was 40 min. The compns. of some of the resulting melts are I-A, I-B, I-C, II-A, II-B, and II-C. Chromium has not been found in any of the melts which shows that Cr_2O_3 does

	SiO_2	FeO	Fe_2O_3	Al_2O_3	MnO	CaO	MgO	Cr_2O_3
A	94.71	...	0.82	0.58	Tr.	1.40	0.49	..
B	92.27	...	1.25	1.53	Tr.	1.87	0.37	2.06
C	88.90	...	1.30	2.64	Tr.	1.97	0.40	4.76
I	59.68	17.36	..	2.34	13.39	2.81	4.10	..
II	54.08	26.91	..	1.28	13.17	2.01	2.52	..
III	44.25	34.25	..	2.66	13.85	3.27	2.36	..
IV	34.61	58.04	5.12	0.48	0.54	0.56	0.31	..
I-A	84.89	6.58	..	1.80	3.36	2.19	1.19	..
I-B	62.61	16.59	..	2.13	13.03	2.41	2.86	..
I-C	62.54	18.44	..	2.21	11.77	2.63	2.63	..
II-A	63.20	23.30	..	1.88	8.37	1.43	1.34	..
II-B	57.63	23.94	..	1.92	12.93	1.45	1.47	..
II-C	56.87	26.51	..	2.07	11.62	1.49	1.23	..

not react to form a fusible compound. It is seen that an increase of Cr_2O_3 in the silica pots from 2 to 5% has only a small influence on their resist. to corrosion. O. A.

Preparation (in the electric furnace) of artificial sillimanite for refractory uses. C. E. SIMS, HEWITT WILSON AND H. C. FISHER. *Trans. Am. Electrochem., Soc.* **46,** preprint (1924).—Neither indirect- nor direct-arc furnaces seem practical for the melting of Al silicate, because of the low-heat and elec. condy. of this substance. A furnace employing resistance heating, with the electrodes fairly close together and the current flowing through the molten bath, gave the best results. Artificial sillimanite may be

prepd. by melting materials of the proper proportions of Al_2O_3 and SiO_2 or by melting clay and removing the excess SiO_2 by reduction with C. The SiO_2 is removed partly as Si and partly as SiO_2. Although natural sillimanite has the compn. $Al_2O_3.SiO_2$ with an alumina:silica ratio of 63:37, artificial sillimanite always has the compn. $3Al_2O_3.2SiO_2$ with a ratio of 72:28. Artificial sillimanite of an alumina content below the 3:2 compn. crystallizes in long vitreous needles, but that above this ratio is stony and finely crystd. As a refractory, the vitreous material is inferior to the stony. The stony sillimanite brick, which may be called sillimanite-corundum brick, stand a higher load test than silica, spall less than either silica or magnesite, last longer than either silica or magnesite in a high-lime or high-Fe slag, and are as good as silica in an acid slag. When lime as an impurity in sillimanite exceeds 1.5%, it causes a serious reduction in the fusing temp. C. G. F. (*C. A.*)

Refractory materials used in the construction of coke ovens. V. Bodin. *Chemie et industrie*, **Special No.**, 415–29(May, 1924).—A discussion of the requirements which coke-oven refractories should meet, of lab. tests for estg. these properties, and of the qualities of various classes of materials (silico-aluminous contg. less than 25% Al_2O_3; aluminous contg. 30–40% Al_2O_3; ultra-aluminous contg. over 40% Al_2O_3; bauxite; SiO_2). A. P.-C. (*C. A.*)

Refractory linings. W. H. Gaylord, Jr. *Oil & Gas News*, **14**, No. 2, 24–8(1924).—The use of high-temp. cement in place of fire clay in building furnace linings enables the brick to be laid with a very thin joint and the wall bounded throughout its entire thickness at atm. temps. It is desirable to give the entire inner surface of the brickwork a coating of this cement which prevents attack of the brick by flame and hot gases. Details of furnace construction and reconstruction and the use of insulating brick are discussed. D. F. B. (*C. A.*)

BOOK

Refractory materials, fire clays, analyses and physical tests. F. R. Ennos and A. Scott. **28**, Special Reports of the Mineral Resources of Great Britain. London: H. M. Stationery Office, 1924. Price 3 s. H. H. S.

PATENTS

Thoria-crucible production. Henry Kneeland Richardson and Theodore MacLean Switz. U. S. 1,512,801, Oct. 21, 1924. As a slip for casting refractory ware a homogeneous mixture of incompletely shrunk thoria, grog, a medium adapted to serve as a colloid, a reagent capable of developing an electrolytic action in the presence of water, in the proportion of 40, 20, 5 and 2 parts, respectively, and water to the desired consistency. The method of making thoria ware, comprising forming a slip of thorium oxide, grog, a double halide salt adapted to serve as a colloid, a reagent capable of developing an electrolytic action in water, and water, subjecting said slip to a vacuum to exhaust any gases therein and casting.

Refractory mortar and cement composition. Charles G. Carlstrum. U. S. 1,511,503, Oct. 14, 1924. The herein-described composition of refractory materials, for the making of refractory mortars, cements or plasters, consisting of fire clay not more than 20% of the total mass, salt not more than 2% of the total mass, and coal ash not less than 78% of the total mass, substantially as described.

Refractory mortar and cement composition. Charles G. Carlstrum. U. S. 1,511,504, Oct. 14, 1924. The herein-described composition of refractory materials, for making of refractory mortars, cements or plasters, consisting of fire clay not more than 20% of the total mass, salt not more than 2% of the total mass, coal ash not less than 68% of the total mass and ganister rock not more than 10% of the total mass, substantially as described.

Neutral cement. Robert H. Youngman. U. S. 1,514,812. Nov. 11, 1924. A

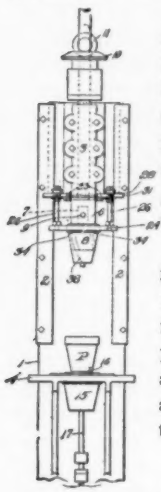
refrac. compn. comprising an intimate mixt. of powdered chrome ore and powdered sodium silicate.

White Wares

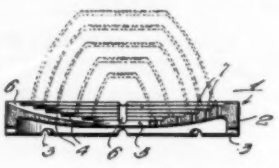
New designs for transmission line insulators. E. ALTMANN. *Electro.-Tech. Zeit.*, 1022(1924).—A discussion of some of the faults of porcelain insulators is followed by the explanation of the features of the new designs. These insulators are shown to be sufficiently strong in tension for the service demanded. Elaborate tests were made as to their resistance to stones and bullets. They differ from the conventional design in that they are cement free in assemblage. The insulators are essentially a porcelain bar with expanded ends for attaching hardware, which is attached by a low melting alloy instead of cement. One or more insulating flanges of large diameter may be built into the unit. Units may be connected giving greater insulation value. Tables are appended showing characteristics of new design. J. T. L., JR.

PATENTS

Device and method for forming ceramic objects. ALBERT CHAMPION. U. S. 1,491,079. This is a device for grinding spark plug porcelains. P. D. H.



Pottery trimmer. JOSEPH M. MACCARRAGHER AND ANSELMO GOVONI. U. S. 1,513,840, Nov. 4, 1924. In a pottery molding machine, the combination of a mold having a recess formed at its rim that opens into the cavity of said mold; a core movable into and out of said mold provided with a chine shaping shoulder; and a feather removing member movable into a position within said recess and immediately adjacent the side of the article being molded so that it is in the plane of the joint between said shoulder and the rim of the mold when the core is fully within the latter.



Ware support and process of burning ware. SYDNEY MACKEY. U. S. 1,515,063, Nov. 11, 1924. A support for ware while burning the same, comprising a plurality of sepd. supporting areas surrounding one another and adapted to engage the edges of a plurality of inverted nested receptacles to be burnt.

Equipment and Apparatus

Viscosity determinations in ceramics. ERNST P. BAUER. *Trans. Ger. Ceram. Soc.*, **5**, 2(1924).—Describes the patented Fischer-Bauer viscosimeter consisting of a fine gilded copper wire running over a small brass pulley to one end of which is attached a small spherical weight which descends into the container containing the clay slip and to the other end a counterweight slightly lighter whose function is to retard the falling motion and permit closer measurements. The apparatus is adjusted so that the one weight just touches the surface of the slip and the counterweight is then 30 cm. from a stationary marker. The weight is then released and the time measured with a stop watch that it takes the weight to travel down through the slip for a distance of 30 cm. To obtain the true viscosity these results can then be compared with some standard liquid such as glycerine by using the formula $V:V' = ST:S'T'$ where $T + T'$ = the time and $S + S'$ the sp. gr. of the liquids. F. A. W.

New double revolving screen. ANON. *Brick & Clay Rec.*, **65** [1], 54(1924).—The screens revolve in opposite directions. The inner screen is 48 in. in diam. and 9 ft. long. It is divided into 3 sections and runs 16 r. p. m. It acts as a scalper and dis-

tributor. The outer screen is 72 in. in diam. and 9 ft. long. It is divided into 3 sections and runs 10 r. p. m. The normal position for opern. is 20 degrees to the horizontal. It is possible to screen clays higher in moisture content because the finishing screen is vibrated (by hammers) when it is not covered with mat. The screen has a capacity of 4 ordinary 9 ft. dry pans. P. D. H.

Confine dust in the dry pan. ANON. *Brick & Clay Rec.*, **65** [4], 108(1924).—Much of the dust nuisance resulting from the grinding opern. can be obviated by covering the dry pans with a canvas. A picture is shown of one such effective arrangement. P. D. H.

Doing away with coal wheelers. ANON. *Brick & Clay Rec.*, **65** [4], 108(1924).—A set of tracks are laid between the rectangular kilns and elevated from 12 to 18 in. above the ground level. These "stub" tracks are placed at right angles to a main line track running between the 2 rows of kilns. The transfer car, on which are set 2 small side dump cars, is drawn by a gasoline locomotive over the main line. The dump cars are rolled by the workman to any desired location. P. D. H.

New type of viscosimeter. G. GALLO AND M. TENAMI. *Giorn. chim. ind. applicata*, **6**, 280–3(1924); *Jour. Soc. Chem. Ind.*, **43**, B851(1924).—The instrument consists essentially of 2 parallel metal discs which can be rotated about the same geometrical axis a short distance apart. The lower disc is capable of slow uniform rotation, the rate of which is indicated on a speedometer. The rotation of the upper disc is restricted by a spiral spring, the deviation of the disc from its normal position of rest being a measure of the force tending to make it turn. When the chamber contg. the 2 discs is fitted with the liquid to be examd. the rotation of the lower disc causes the upper one to turn to a position dependent on the viscosity of the liquid. If E is the ratio between the respective times of efflux of equal vols. of the liquid and of distd. water at 20°, D the deviation of the upper disc, p the sp. gr. of the liquid, and n the number of revolutions per minute of the lower disc, $E = \frac{CD}{2pn}$ approx. and $E = \frac{CD}{2pn} + \sqrt{\left(\frac{CD}{2pn}\right)^2 + 0.8632}$ exactly where C is a constant to be detd. empirically for each instrument. H. H. S.

The gasoline or electric shovel. H. S. STROUSE. *Brick & Clay Rec.*, **65** [4], 110, (1924).—The half yd. shovel will handle clay enough for from 70,000 to 100,000 brick per day, depending on facilities for switching and handling. A saving of from $14.00 to $20.00 per day is effected in the opern. of either a gasoline or elec. shovel in place of a steam shovel. An elec. shovel of $^3/_4$ yd. capacity will use approx. 10 k. w. hrs. per hr. P. D. H.

What a poidometer will do. G. C. WEILAND. *Brick & Clay Rec.*, **65** [4], 111 (1924).—The poidometer in conjunction with the liquidometer attachment will feed the clay to the pug mill and temper it with a precision unattainable by a pug mill operator. Even tempering minimizes drier and kiln losses and insures a constant flow of ware. Poidometers can also be used in the fire brick indus. for proportioning mats. to be delivered to the wet pans. They are wired in battery and will automatically stop, should any one fail to receive its supply of mat. The entire unit will automatically resume opern. when the missing mat. is supplied. The capacities vary from 12 T. to 100 T. per hr. The amt. of mat. handled by the mach. in a given unit of time can be readily noted by reading the productimeter. P. D. H.

Gasoline locomotive spells economy. B. EISENMAN. *Brick & Clay Rec.*, **65** [4], 111(1924).—One small gasoline locomotive will replace from 2 to 6 horses and mules, and a corresponding number of drivers. Locomotives ranging from 1 to 4 T. vary in draw bar pull from 500 to 2000 lbs. On the av. haul over from $^1/_2$ to $^3/_4$ of a mile of track, the gasoline consumption of a 1 T. truck power unit will vary from 5 to 7 gals. per day for moving 100 T. of clay. P. D. H.

A few hints on clay plant hauling equipment. B. F. TOWNSLEY. *Brick & Clay Rec.*, **65** [1], 30(1924).—The particular type of mechanical haulage for a given plant depends on local conditions. Rope haulage should be employed in plants where the pit is located near by and the grade is above 2½%. If less than 2½% other methods may be resorted to with a possible saving. A 1% grade takes almost double the energy that is necessary to move a load on a level track. In general practice, the haulage capacity of a locomotive is 13 T. per ton of locomotive weight, on the level, while with a 1% grade this is reduced to 8 T. and with a 5% grade to 3 T. The gasoline or elec. type of locomotive is generally preferred to steam. The advantages of the former are its low first cost, which is about $750 per T., its simplicity of opern. and normal fuel consumption cost of about $1.00 per T. weight per day. This type would accordingly be desirable in plants where requirements are for a less-than-three-ton locomotive. Elec. locomotives propelled by storage batteries offer a reliable, flexible and economical source of power. The first cost per T. weight is about $1400 and the cost to operate is about 10c per T. per day, and often less as the batteries are charged at night during the off-peak load of the plant. The proper size and type of car is another important factor. Standard practice dictates the use of the V-bottom, steel, side dump cars, where, in many instances, more efficient types could be used. Storage battery trucks are now being used for coal distribution, ash removal and green and fired ware transportation. Portable platforms facilitate the movement of ware. A truck of this type with one man can equal the capacity of from 5 to 10 men with wheelbarrows. P. D. H.

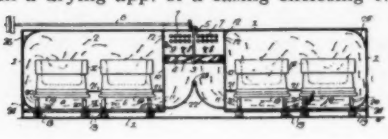
Herbert pendulum hardness tester. C. BENEDICTS AND V. CHRISTIANSEN. *Jour. Soc. Chem. Ind.*, **43,** B836(1924).—The Herbert pendulum provides 2 independent tests of hardness, *viz.*, the time test, which gives the indentation hardness and corresponds to the Brinell test, and the scale test, which measures the work hardness or resist. of working with a tool. The ratio of scale of time hardness measures the flow hardness or resist. to flow. The motion of the pendulum ball is shown to be a purely rolling one. The decrease in the time-test number is due to the fact that the softer the metal, the greater is the depth of indentation. H. H. S.

An improved way of washing ocher. A. H. HUBBELL. *Eng. Mining Journal-Press*, **118,** 336–8(1924).—A new slime separator, which overcomes the losses in the use of settling tanks for sepg. this non-metallic min., is found valuable. A sepg. tank 14 ft. in diameter receives the mat., the coarse sand settles against a rising stream of water which is adjusted so as to effect the sepn. of sand and slime. The slime, minus 300-mesh, passes over the edge of the cone in the form of a slurry to Dorr thickeners, and thence to agitating tanks and to the sprayer box. From the sprayer box the thickened ocher is passed on to a drum drier, removed, and fed by a screw conveyor to a hammer pulverizer. The coarse sand passes to the bottom of the cone separator and discharges into a cylinder where it is agitated and scrubbed by the flight conveyor. The particles of ocher thus freed are pumped back into the top of the cone. This separator is giving a recovery of 96 to 98% of the ocher. H. G. F.

The thickening and hardening of ceramic pulps. J. MANDRON. *Rev. gén. colloids*, **2,** 41–5(1924).—A description of the Hertenbein continuous rotary filter, with a discussion of its merits in thickening ceramic pulps. A. P.-C. (*C. A.*)

PATENTS

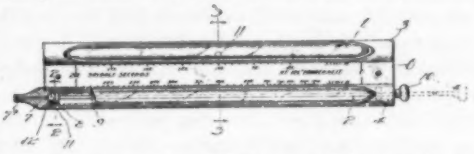
Drier. THOMAS H. RHOADS. U. S. 1,513,932, Nov. 4, 1924. The combination in a drying app. of a casing enclosing two drying chambers and an intermediate circulating, htg. chamber sepd. by vertical partitions having upper and lower passages therein; a series of horizontal circulating fans mounted on vertical shafts, means for driving said shafts; a series of heating coils in the



intermediate chamber; means for supplying moisture to the air in circulation, the lower portion of the intermediate chamber being curved so as to direct the air to each of the drying chambers; cars in the drying chambers on which the articles to be dried are mounted, partitions between the cars, the outer ends of the drying chambers being curved; and means for separating the drying chambers and the circulating chamber into independent compartments.

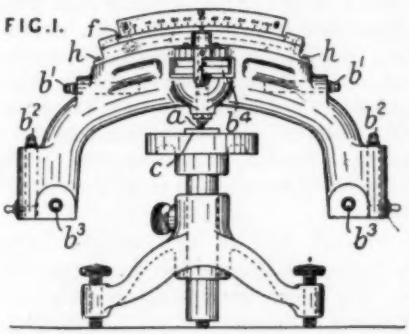
Process of drying hollow articles. ELWOOD B. AYERS. U. S. 1,513,881, Nov. 4, 1924. The process herein described of drying hollow articles having open tops, said process consisting in circulating heated air first under each article and then past the opening therein at a speed sufficient to cause a partial vacuum to be formed within each article to cause a circulation of heated air in the articles.

Viscosimeter. CLIFFORD M. LARSON AND CARL L. KNOPE. U. S. 1,511,998, Nov. 4, 1924. In a device for ascertaining the fluidity of liquids, the combination with parallel tubes, one of said tubes having a liquid of a predetd. fluidity therein, of suction means for drawing the liquid to be tested into the adjacent tubes, means movable with the inclination of the tubes and mounted therein, the relative speed of said movable means through the respective mediums registering the fluidity with the inclination of the tubes.



Method of and means for testing the hardness of metals and other materials. E. G. HERBERT. E. P. 207,876/22. *Jour. Soc. Chem. Ind.*, **43**, B320(1924). A test member, *a*, of hard material, *e. g.*, sapphire or hardened steel, weighted by a member formed with a central arched portion and vertical end parts, is caused to roll or oscillate on the surface of the material, *c*, to be tested, adjustably supported on a table carried by an adjustable stand or tripod. Means are provided whereby the center of gravity of the weight member when in neutral equilibrium may be made to coincide with the center of curvature of the test member, *a*. By rotating the disc, b^4, the center of gravity of the instrument may be adjusted above or below the center of curvature of *a* and the length of the equivalent pendulum altered accordingly. In making a test, the center of gravity of the weight member is adjusted to lie below the center of curvature of *a*, and the pendulum tilted from the vertical position until the air bubble of a spirit level, *f*, indicates 0 on the inclinometer scale. When released, the pendulum rolls along the elongated indentation produced in the test member, and a measure of the comparative hardness of the material under test is obtained by observing the amplitude of the first oscillation of the pendulum after being released. Alternatively the hardnesses of various materials may be compared by determining the times taken for a given number of oscillations of the pendulum when supported on the respective materials. Hardness numbers so determined are convertible into Brinell hardness numbers and extend into regions of hardness where the Brinell test is not applicable.

FIG. 1.



Kilns, Furnaces, Fuels and Combustion

Lignite as a fuel in the Ceramic Industry. CHR. HEUER. *Feuerungstech.*, **12** [24], 214(1924).—Lignite, either raw or in the form of briquettes, can be used to ad-

vantage for temps. ranging between 700–1500°C on account of its high gas content which generates a much longer but cooler flame than hard coal. Kiln temps. of 1150° have been reached with the raw lignite and of 1300° with briquettes. Emphasis is laid on (1) combustion chamber must be large on account of high gas content of the fuel and to insure complete combustion, (2) a minimum of poking should be done so as not to break up the briquettes. Long flues under the bottom of the kiln are advisable to utilize the full heat of the long flame. A down-draft kiln measuring inside 39′-6″ x 15′ x 11′ high showed a temperature difference of only $^1/_2$ cone between top and bottom. Comp. figures taken from a continuous kiln showed that to fire 1000 brick (79,200 lbs.) 1045 lbs. of raw lignite were required against 330 lbs. of hard coal. Air necessary for combustion was 32% less than with the coal. F. A. W.

A new idea in kiln construction. ANON. *Brick & Clay Rec.*, **65** [5], 173(1924).—P. J. Lengsholz is the inventor of the Lengsholz Improved Brick Kiln. The only change necessary to the av. down-draft kiln is in the bag walls and the addn. of a separate water smoking flue leading to the base of the stack. This flue extends up into the kiln between 2 bag walls and in part of the kiln wall. The side of the flue facing the inside of the kiln is open and the top is arched over. A number of holes approx. 6 in. by 10 in. are built in the front of the bag walls at from 12 to 18 in. above the floor. A cross draft is thus produced which carries the ht. entirely through the ware until it reaches the water smoking flue. By raising and lowering the dampers alternately in the 2 flues the temp. of the kiln is kept uniform from top to bottom during the entire burn. During the water-smoking period, the bag wall openings are kept entirely open after which about $^3/_4$ of their area is closed. A fuel saving of from 25 to 50% is said to be accomplished together with a considerable saving of time. A sectional plan and elevation are shown. P. D. H.

Firing brick with city gas. ANON. *Brick & Clay Rec.*, **65** [5], 167(1924).—The use of city gas, at the plant of the Lake View Brick Co., Chicago, Ill., has lowered the firing time from between 68 and 72 hrs. to between 29 and 35 hrs. or better than 50%. The quality of brick around the arches has also been improved. The labor ratio is better than 2 to 1 (approx. 66%) in favor of gas. No statistics are given on comparative fuel costs. A gas compressor boosts the gas press. to 15 lbs. and delivers it to the burners at about 12 lbs. press. A burner of simple pipe construction is used. The gas is turned on slowly until the brick in the vicinity of the arch are through water smoking and then the gas is turned on full until the arch brick attain a "cherry" red color. The gas is then turned down and the ht. permitted to travel upward to a point about $^5/_8$ of the way up, when the gas is turned off entirely. P. D. H.

Protecting the firemen. ANON. *Brick & Clay Rec.*, **65** [4], 108(1924).—The fireboxes on a tunnel kiln were equipped with chain curtains hung from a swinging iron bar or pipe located directly over the firebox. The chains permit the fireman to look into the firebox from close range without discomfort to the eyes. P. D. H.

The insulation of periodic kilns. E. A. PHOENIX. *Brick & Clay Rec.*, **65** [4], 112 (1924).—The advantages of Sil-O-Cel kiln insulation are: Greater fuel economy, improved quality of burn, reduction in firing time and longer life of crowns, walls and fire pockets. For thoroughly insulated kilns, the saving in fuel consumption ranges from 16 to 20%. Insulation of the crown alone results in a saving of from 8 to 10%. Base insulation, in addn. to effecting a considerable fuel saving, is an important factor in increasing the bottom temp. The quality of the ware is improved because of the greater uniformity of ht. distribution. One refrac. plant reduced the percentage of soft brick from 1.2 to 0.25% after insulating crowns and bottoms with Sil-O-Cel brick. Insulated kilns are not susceptible to atmospheric conditions. At one plant, where the bottoms and crowns were insulated, the firing time was reduced from 163 to 135 hrs.

The life of the crowns and walls is prolonged because of the reduction in internal stresses and since the necessity of forcing fires is obviated to a great extent, the life of the fire pockets is also lengthened. The bottoms are usually insulated with either one or two $2^1/_2$ in. layers of Sil-O-Cel brick or 5 in. of Sil-O-Cel C-3 concrete; the side walls with $4^1/_2$ in. of either Sil-O-Cel brick or powder; and the crowns, with either one or two $2^1/_2$ in. layers of Sil-O-Cel brick, laid with Sil-O-Cel mortar and covered with a plating of common brick. Crowns should be waterproofed with Celcote which is a coal tar product especially designed for the purpose. Comparisons in ht. losses between insulated and uninsulated walls and crowns of varying construction are shown in 2 figs. A sectional drawing details the method of insulating round down-draft kilns. P. D. H.

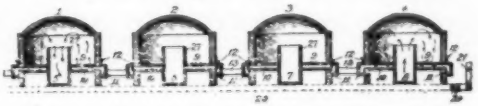
Industrial ceramic furnaces. BRÉMONT. *Chaleur & industrie*, Dec., 1923; *Rev. universelle mines*, **3** [7], 115–6(1924).—A review and discussion of the principles involved in the construction and operation of ceramic furnaces and the most efficient types and of methods for mfg. terra cotta, faience, brick, refractory products, opaque and transparent vitrified products, stoneware and porcelain. C. C. D.(*C. A.*)

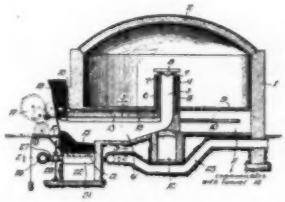
Use of purified gas in the ceramic industry. J. KAVAN. *Chimie et industrie*, **Special No.,** 222–3(May, 1924).—Coal contg. 35.12% H_2O and 15.35% ash was gasified in rotary grate producers, and the gas, cooled to 100° to sep. tar, contained: CO_2 5.5, O 0.4, CO 27.0, H 10.7, CH_4 3.1, N 53.2%, calorific value 1350 cal. per cu. m. at 0° and 760 mm. The gas was used for heating intermittent porcelain kilns, with heat exchanger, and gave a temp. of 1370–1400°, with an efficiency of about 70%.

A. P.-C. (*C. A.*)

PATENTS

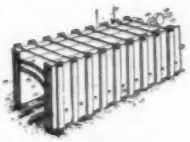
Kiln. WILLIAM E. WILSON. U. S. 1,513,778, Nov. 4, 1924. In a structure of the character described, a kiln having a plurality of ducts beneath the floor thereof, exhaust means connected therewith, means for controlling the connection between the ducts and the exhaust means, and a perforated floor adapted to permit heated air and gases to be drawn therethrough into the said ducts, the said floor being formed of a plurality of layers, the first of which comprises elongated members, laid transverse to the ducts, and with elongated spaces therebetween, and the second of which is laid transverse to the first.





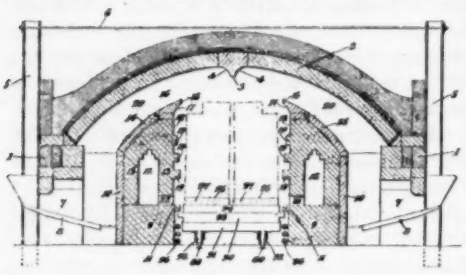
Kiln construction. ENOCH P. STEVENS. U. S. 1,511,535, Oct. 14, 1924. A kiln, comprising an upstanding flue providing a chamber for the passage of gases and a space surrounding said chamber for the passage of air, said flue being provided with means for directing said gases horizontally and means for directing said air at an angle inclined to the vertical.

Tunnel kiln. JOHN B. OWENS. U. S. 1,510,556, Oct. 7, 1924. A tunnel kiln provided with a heat collecting chamber extending lengthwise thereof for substantially the extent of the cooling and burning zones in position to receive heat radiating from that part of the tunnel comprehending the burning and cooling zones, means for admitting outer air into said chamber, and means for inducing draft in said chamber to thereby draw outer air thereinto and to cause the warm air therein to be delivered from said chamber for utilization.



Tunnel kiln. WILLIAM LEE HANLEY, JR. U. S. 1,511,218, Oct. 7, 1924. In a tunnel oven, the combination with a firing chamber having a goods space extending

longitudinally thereof, direct firing furnaces for said chamber, said chamber being provided with discharge passages for said furnaces communicating with said chamber near the top thereof, and means for deflecting the products of combustion downward centrally of the goods space, receiving flues located on opposite sides of said chamber, and interposing an imperforate wall between the said passages and the goods space, said receiving flues being provided with inlet ports on their inner faces adjacent to the lower portion of the goods space, and means for preventing the products of combustion discharged from said discharge passage into said chamber from passing downwardly therefrom between the goods and the inner walls of the receiving flues.



Geology

Investigations on Norwegian clays. IV. B. DIETRICHSON. *Norges Geologiske Undersokelse*, **120,** 1–52(1924).—Descriptions of quaternary clay deposits and of brick works situated in North Norway, accompanied by photographs of the works and pits, and sketch maps and profile sections illustrating the geology. O. A.

Mattagami china clay deposits. ANON. *Canadian Chem. & Met.*, **8** [11], 266 (1924).—A deposit of china clay has been discovered along the Mattagami River District of Timiskaming, Ontario. There are frequent outcrops and little overburden. The bottom of the deposit was not reached at 75 ft. A very pure glass sand is associated with the clay. Analyses are:

	Clay per cent	Sand per cent
SiO_2	49.40	99.1
Al_2O_3	35.79	0.324
Fe_2O_3	0.13	0.176
CaO	slight trace	trace
MgO	slight trace	trace
Loss on ignition	13.85	

The deposit is 30 mi. from the terminus of the T & N O R R. A "tote" road is being cleared. F. G. J.

The composition of thomsonite. S. G. GORDON. *Proc. Acad. Natural Sci. Phila.*, **76,** 103–7(1924).—Previous work on the formula of thomsonite is reviewed, and the replaceability of Na by Ca is pointed out; then, disregarding this, the results of 55 analyses are recalcd. to mol. ratios, Na_2O being taken as 1. $CaO + Na_2O$ are plotted against SiO_2 and against H_2O, and the ratio-points found to fall on fairly definite lines. Certain points on these lines are assumed, without reasons being given, to represent end-members of some sort of series. Superior analyses of 3 "thomsonites" [all of which have been shown to be optically distinct from this mineral, however, *C. A.*, **17,** 2845] are compared with theoretical values calcd. by the formula $n(CaO + Na_2O).nAl_2O_3.2n + SiO_2.3n - 2H_2O$, and good agreement is shown. It is concluded that "the thomsonite series can be interpreted as mixed crystals of the end-members: $CaO.Al_2O_3.2SiO_2.3H_2O$ (calciothomsonite) [and] $Na_2O.Al_2O_3.3SiO_2.H_2O$ (natrolite 'with' 1 H_2O)" [should read "less 1 H_2O"]. [The optical demonstration that some of the analyses of so-called thomsonite have been made on mixtures with natrolite is thus confirmed, but no new light is thrown

on the compn. of thomsonite with definite optical-crystallographic properties.—Abstractor.] E. T. W. (*C. A.*)

Production of alumina from clay and other materials. V. M. GOLDSCHMIDT. *Tids. Kemi Bergvaesen*, **4**, 38(1924).—Polemical. The calcns. of the economy of the clay process given by H. Pedersen (*Ceram. Abs.*, **3** [4], 108) are criticized. C. H. A. R. (*C. A.*)

Production of alumina from clay. HAROLD PEDERSEN. *Tids. Kemi Bergvaesen*, **4**, 55–6(1924).—A reply to Goldschmidt (preceding abstract). See also *Ceram. Abs.*, **3** [4], 107. C. H. A. R. (*C. A.*)

Chemistry and Physics

Reddish discoloration of opaque tin oxide glazes. R. RIEKE. *Trans. Ger. Ceram. Soc.*, **5**, 2(1924).—The research laboratory of the State Porcelain Works, Berlin, traced the discoloration to a small amt. of chrome salts present in the red lead oxide, the charac. bright red color of which had been preserved by the addn. of organic coloring matter. The quantity present was too small to be revealed by analysis and on investigation it was found that as low as 0.0025% chrome oxide led to a decided discoloration. On this account lead oxide should be closely watched for traces of chrome. Tests also showed that the discoloration developed under oxidizing conditions and disappeared if the glaze was subjected to a reducing atmosphere. F. A. W.

Chemical fumes. I. Size of particles. H. REMY. *Z. anorg. Chem.*, **138**, 167–79 (1924); *Jour. Soc. Chem. Ind.*, **43**, B867–8(1924).—The Stokes-Cunningham formula was used to calc. the size of drops from the rate at which the fumes sink in air. Owing to the agglomeration of the initial drops to form larger particles, the rate of fall of a newly prepd. fume first increases and then attains a constant value. The radius of moist fumes of ammonium chloride increased from 6.2×10^{-5} to 11.9×10^{-5} cms., and of sulphur trioxide from 5.3×10^{-5} to 12.6×10^{-5} cms. H. H. S.

Structure of "black diamonds" (carbonado). W. GERLACH. *Z. anorg. Chem.*, **137**, 331–2(1924); *Jour. Soc. Chem. Ind.*, **43**, B868(1924).—X-ray examn. of carbonado indicates that it is a conglomerate of interpenetrating crystals of diamond, the individual crystals being covered with a layer of graphite or amorphous carbon. H. H. S.

Titration of silver and halogen ions with dyestuff indicators. K. FAJANS AND H. WOLFF. *Z. anorg. Chem.*, **137**, 221–45(1924); *Jour. Soc. Chem. Ind.*, **43**, B851(1924).—For the titration of silver and alkali halides, fluorescein is the most suitable indicator in the case of chlorides, and dibromo-fluorescein or eosin for bromides. The amt. of iodide in a mixt. contg. chloride is detd. by titrating 1 part of the soln. with fluorescein as indicator, and another part with dimethyl-di-iodofluorescein; the first titration giving the sum of the 2 halides, and the second the iodide alone. A correction previously ascertained with known mixt. is applied. H. H. S.

The Pemberton-Neumann method for the estimation of phosphorus. M. B. RICHARDS AND W. GODDEN. *Jour. Soc. Chem. Ind.*, **43**, 1009(1924).—(Meeting, Soc. Public Analysts, Oct. 1.) Sources of error in this method are: (1) absorpn. of CO_2 by the alkali used to dissolve the ammonium phosphomolybdate ppt., and (2) the use of a wrong factor. Errors due to (1) may be eliminated by boiling with excess of acid before final titration. (2) The authors use the factor 0.001365 instead of Neumann's 0.001268, believing that their ppt. is $(NH_4)_3PO_4$, 12 MoO_3. The new factor gives results closely agreeing with those obtained gravimetrically. H. H. S.

Hydrofluosilicic acid III. Method of titrating and properties. C. A. JACOBSON. *Jour. Phys. Chem.*, **28**, 506–9(1924); *Jour. Soc. Chem. Ind.*, **43**, B827(1924).—Titrate first at 0 with $N/1$ alkali, adding KCl or NaCl and using methylorange as indicator;

then near b. p. using phenolphthalein as indicator. Hydrofluosilicic acid is non-volatile, and is stable only in aqueous soln. in which it may be concd. to approx. 61%.
H. H. S.

Method of dissolving chromic oxide. T. SABALITSCHKA AND F. BULL. *Z. anal. Chem.*, **64,** 322–5(1924); *Jour. Soc. Chem. Ind.*, **43,** B828(1924).—Fuse with mixt. of 2 parts sodium carbonate and 1 part sodium nitrate. H. H. S.

Color reactions for zirconium and fluorine. J. H. DEBOER. *Chem. Weekblad*, **21,** 404–5(1924); *Jour. Soc. Chem. Ind.*, **43,** B852(1924).—Zr salts give a reddish violet color with alizarinsulphonic acid which is stable in large excess of HCl, but with further acid changes to orange. The color is completely discharged by addn. of traces of fluoride. H. H. S.

New methods of volumetric analysis. K. JELLINEK AND W. KÜHN. *Z. anorg. Chem.*, **138,** 81–103; 109–34(1924); *Jour. Soc. Chem. Ind.*, **43,** B853–4(1924).—Methylene blue may be used as indicator in titrating bichromate with thiosulphate, and in all cases where a reducing agent such as sodium sulphide is treated with excess of bichromate and the excess titrated by thiosulphate. Potassium permanganate is a satisfactory indicator for titrating zinc with ferrocyanide, the pink disappearing as soon as the ferrocyanide is in excess. Zinc and manganese in boiling solns. may be titrated with sodium sulphide using phenolphthalein as indicator, but there is a constant error in sulphide excess of 8% in case of zinc, and 6% in case of manganese. Al or Pb in soln. may be titrated with disodium phosphate using methyl red as indicator. H. H. S.

The determination of the thermal conductivity of technical materials. O. TESCHE. *Z. tech. Physik*, **5,** 233–6(1924).—Methods of measurement and the necessary app. are described, which includes a discussion of the sources of error in measurements of this sort. The following data have been obtained on thermal condy. (cal./cm. degree sec.): India rubber (35%) 0.000549, (50%) 0.000477, (90%) 0.000331; transformer oil 0.000310; gelatin soln. 0.00133; celluloid (unknown mixt.) 0.000514; graphite I (unknown mixt.) 0.0165; graphite II (unknown mixt.) 0.0181. J. H. P. (*C. A.*)

The recovery of aluminium from clay. H. SPECKETER. *Z. physik. Chem.*, **110,** 514–20(1924).—Formerly Germany was dependent upon other countries for bauxite from which Al was recovered but the World War forced the development of recovering Al from clay. An av. analysis of the clay used is: SiO_2 53, Al_2O_3 39.7, Fe_2O_3 2.9, TiO_2 3.6%. Both alkali and acid processes are used. The difficulty with the alkali process is in freeing the Al_2O_3 from SiO_2 and with the acid process freeing the Al_2O_3 from Fe_2O_3 and TiO_2 and in recovering the acid. In the alkali process the clay is treated with CaO and Na_2CO_3 at 1100–1200°. $Al_2O_3.2SiO_2 + 4CaO + Na_2CO_3 = Al_2O_3.Na_2O + 2SiO_2.-4CaO + CO_2$. In the acid process the temp. is 700–800°. Either H_2SO_4 or HCl may be used. See also *Ceram. Abs.*, **3** [11], 329(1924). C. H. K. (*C. A.*)

The two schools of colloid scientists. PAUL BARY. *Rev. gén. colloides*, **1,** 39–45 (1923).—The "physical" theory of colloids considers that all matter in a certain region of dispersity is colloidal. According to this theory colloidality is merely a state of matter. B. prefers the "chem." theory according to which the term "colloid" is reserved for those substances which polymerize readily, swell in certain media, exhibit rather indefinite chem. reactions, are amorphous and "melt" to viscous fluids, and possess a peculiar method of going into soln. in the liquids in which they swell. "Colloids" in this sense may yield true solns. under certain circumstances. *E. g.*, the soaps and many dyestuffs give colloidal solns. in H_2O and true solns. in alc. With a glass with small crystals of a metal the physical theory regards the highly dispersed but cryst. metal as constituting a colloid, whereas the chem. theory considers that it is the amorphous, highly polymerized glass itself which is the colloid. The differences between the 2 theories are not so much matters of fundamental conception as of nomenclature and

point of view. The chem. theory is claimed to be more nearly in line with Graham's views. According to the chem. theory the fact that a substance does not pass through a dialyzing membrane has nothing to do with its colloidality. The difficulty of distinguishing sharply between emulsoids and suspensoids is due largely to the attempt to employ the physical theory. According to the chem. theory the suspensoid or lyophobe colloids are *colloidal suspensions* whereas the sols produced in media in which the substance swells, such as gelatin in water below 35°, are *colloidal solutions*. By mech. means gelatin in water below 35° can be dispersed as very fine particles of gel but this is a colloidal suspension, not a soln. At very high dilns. colloidal solns. tend to become true solns. A *sol*, as the term is now used, may or may not be colloidal according as the dispersed phase is or is not a colloid and according to the nature of the dispersion medium. A colloidal soln. is always formed of particles of a colloidal material which is chemically bound to a part of the medium in which it is dispersed.

F. L. B. (*C. A.*)

Heat conduction in minerals, rocks, and artificial substances of similar composition. K. SCHULZ. *Fortschr. Mineral. Krist. Petrog.*, **9**, 221–411(1924).—A comprehensive review, with a 16-page bibliography including: introduction, historical survey, relative and abs. methods for detg. thermal condy., dependence of heat conduction in solids on such factors as temp., pressure, crystn., etc., and detailed tables, in which published numerical data are assembled. E. F. H. (*C. A.*)

BOOK

The theory and application of colloidal behavior. Edited by R. H. BOGUE. Vol. I—Theory; Vol. II—Application. New York, McGraw-Hill Book Co. (1924).

H. H. S.

PATENTS

Production of aluminum-alkali double fluorides technically free from iron. A. L. MOND. *Chem. Fabr. Griesheim-Elektron.* Eng. Pat. 203,708, Sept. 8, 1923. *Jour. Soc. Chem. Ind.*, **43**, B869(1924).—Clay and the like are treated with min. acids, and the double fluoride is pptd. from the soln. by adding HF and alkali salts, or alkali fluorides and H_2SO_4 or HCl. The iron is either reduced first to ferrous by H_2S or, if ferric salts are present, the quantities of reagents are adjusted so that a small amt. of Al salt remains in soln. H. H. S.

Separating zirconium and hafnium. H. WADE. *Naaml. Vennoots. Philips' Gloeilampenfabr.* Eng. Pat. (A) 220,358 and (B) 220,359. May 9, 1923. *Jour. Soc. Chem. Ind.*, **43**, B869(1924). (*a*) Minerals contg. Zr and Hf, such as alvite, are fused with KF.HF, and if impurities such as Ti, Cb, Ta, are present, these are removed by converting the metals into their hydroxides and oxychlorides and treating the latter with HCl and alcohol whereby the impurities enter into soln. Zr and Hf are sepd. by the fractional crystn. of their double fluorides, the Hf being more sol. than the Zr double fluoride. Crystn. may be effected in the presence of HF and an excess of an alkali salt. (*b*) Hf and Zr are sepd. by the fractional pptn. of their oxides or hydroxides by the addn. to their solns. of bases, or of salts such as sodium acetate or thiosulphate which by hydrolysis or decompn. act as bases. They may also be sepd. by partial soln. of the mixed oxides or hydroxides or by a combination of the 2 processes. Hafnium oxide being more basic than zirconium oxide, the ppt. in the first process contains less Hf, and the soln. in the second process contains more Hf, than the original mixt. H. H. S.

Method of producing calcium arsenate. SAMUEL S. SADTLER. U. S. 1,513,934, Nov. 4. The method of producing calcium arsenate, which comprises the mixing together of a solution of arsenic acid and lime with a third ingredient capable of forming an organic salt of calcium more sol. than calcium arsenate.

Process of making artificial cryolite. HENRY HOWARD. U. S. 1,511,561, Oct. 14,

1924. In a process in which artificial cryolite is formed by the interaction of aluminum fluoride and sodium fluoride in the presence of an ammonium compd. in an aqueous reaction mixt. the steps comprising supplying aluminum fluoride to the reaction mixt. in insol. form and digesting the artificial cryolite product in a soln. of a sodium salt of a strong acid.

Process of producing alumina, alkali, and dicalcium silicate. ALFRED H. COWLES. U. S. 1,514,657, Nov. 11, 1924. The process of obtaining alumina from its silicates which consists in forming a sintered product contg. two mol. weights of lime to one of silica and less than one mol. weight of alkali metal oxide to one of alumina, leaching the product thus obtained and sepg. the alumina contd. in the leached liquor.

General

Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1923-24. *Jour. Soc. Chem. Ind.*, **43**, 1013–4(1924). H. M. Stationery Office, London 1924. Price 3s.—The expenditure for the year was £515,382 of which £103,187 went to 23 research associations. The British Portland Cement Assn., has carried out valuable scientific work, and the industry is receiving subscriptions to carry on without further state assistance. Special consideration has been given to the Scientific Instruments Research Assn. which is said to have achieved valuable practical results. The committee was not so favorably impressed with the results of the Glass Research Assn. but steps will be considered to provide for research in this industry. The facilities at the disposal of the Fuel Research Board are to be increased to test plant or process for low-temp. carbonization of coal. The Building Research Board has investigated the causes of the setting of cement and plaster of Paris, the production of fire-resisting cement, the strength of asbestos cement roofing, and the econ. firing of kilns. The Stone Preservation Comm. is devising methods of recognizing the nature of decay in a variety of stones subjected to varying conditions, and it is hoped to gain insight into the various causes of decay. Grants to research workers and students amtd. £45,303. In discussing these, the report states that bad style and bad work frequently go hand in hand. The defect is attributed to too early specialization. In the last 2 yrs. of school life, science should not be allowed to exclude the humanities. The Council notes with approval a tendency for chemistry students to take topics with a biological training. H. H. S.

What the South offers the clay products manufacturer. ANON. *Brick & Clay Rec.*, **65** [4], 98–103(1924). P. D. H.

A Note on the properties of some alloys of nickel. W. R. BARCLAY. *Jour. Soc. Glass Tech.*, **8** [31], 162(1924).—The outstanding properties of nickel alloys are: great resistance to corrosion, great ductility, strength and toughness, retention of strength at high temps., whiteness of color. Nickel-copper alloys and nickel-chromium alloys are taken up separately and their properties pointed out. General uses of nickel alloys and possible applications are discussed. J. G. P.

Manganese steel in the clay industry. JAMES I. COPPS. *Brick & Clay Rec.*, **65** [5], 177–81(1924). P. D. H.

Tests to distinguish metals. ANON. *Brick & Clay Rec.*, **65** [4], 109(1924).—A table is given containing 5 tests for distinguishing between malleable iron, cast steel and cast iron. Manganese steel can be identified readily by the fact that it will not become magnetized and is not attracted by a magnet. P. D. H.

Alloys resistant to heat and corrosion. J. H. G. MONYPENNY. *Jour. Soc. Glass Tech.*, **8** [31], 150(1924).—The mechanical properties of stainless steel are taken up and comparisons made with ordinary steel. Stainless steels compose a whole series of steels, the relative properties depending upon the carbon content just as in ordinary steels.

Stainless steel responds more readily to tempering than ordinary steel. The results obtained from a tempering experiment with stainless steel and carbon tool steel are given in Brinell hardness numbers. Stainless steel resists tempering up to 500°C, while carbon steel decreases in hardness after 200°C is attained. Stainless steel retains its strength well at 500°C. This mat. is also very resistant to oxidation at fairly high temps. The general engineering uses of stainless steel are taken up, and new types of this mat. are described. Alloys which resist oxidation at very high temps. are discussed and their properties pointed out. J. G. P.

Chemical engineers. *Jour. Soc. Chem. Ind.*, **43,** 1033(1924).—The program of the joint meeting of the Amer. and Eng. chem. engineers in England next year is provisionally as follows: July 5, arrive at Liverpool; July 6–8, Chester; July 9 and 10, the Lakes; July 11, Glasgow; July 12 and 13, Edinburgh; July 14 and 15, Leeds. Visitors leave on July 18 for America. H. H. S.

Definition of the term "ceramics." O. BOUDOUARD. *Chimie et industrie*, **Special No.,** 411–4(May, 1924).—A discussion showing the reasons for the adoption of the definition proposed at the 4th international chem. conference. A. P.-C. (*C. A.*)

ANNUAL MEETING

AMERICAN CERAMIC SOCIETY

February 16-21

Columbus, O.

Always important and profitable, always worth attending, but this year the annual meeting is an occasion of singular importance.

Ceramic education, and especially the part taken by the Universities, has been of immense value to the industries. Beginning 30 years ago, the possible profits accruing industrially from ceramic education have greatly increased.

The occasion of this year's Annual Meeting is the celebrating of the 30th anniversary of the founding of the world's first collegiate department of ceramic engineering.

Seven Industrial Divisions, each with its own program;

A day with the Universities, ten of them;

Plant itineraries and personal meetings with men from all ceramic industries and from all ceramic centers of the country—

These are some of the things planned for your profit.

One and one-half rail fare and 900 hotel rooms have been secured.

Your attendance is expected.

BULLETIN

of the

American Ceramic Society

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

Mary G. Sheerer, H. S. Kirk, R. R. Danielson, H. G. Wolfram	Art, Enamel	G. E. Barton, A. N. Finn, F. A. Harvey, R. F. Ferguson, F. H. Riddle, C. C. Treischel	Glass, Refractories, White Wares	W. D. Gates, B. S. Radcliffe, F. T. Owens, A. P. Potts	Terra Cotta, Heavy Clay Products

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Vol. 4 **January, 1925** **No. 1**

EDITORIALS

A NEW YEAR'S GREETING

This issue of the *Journal* is the first of the twenty-seventh annual publication of the Society. The character and value of this and of the succeeding volumes is for the members of the Society to determine. Twenty-six volumes are now beyond improving. They will continue being a source of inspiration and information but their character is determined.

We have no better or more valuable New Year's greetings than an earnest hope that the printed records of the Society shall be of increasing value in each succeeding year.

CERAMIC EDUCATION

It is of importance to the ceramic industries that ten universities in America are providing laboratories, classrooms and instructors for the purpose of creating and transmitting information on ceramic technology. The ceramic art schools have contributed to the welfare of industrial ceramics or their maintenance has not been worth while. There have been fairly large financial outlays for buildings, equipment and materials and, of more importance, a large amount of human endeavor and personal expenditures of time and money to make these schools successful.

Has all of this been worth while? Are the results tangible, concrete and creditable? Would less specific and more general educational courses in ceramic technology accomplish more, less, or as much?

Such questioning as this is worth while for either the ceramic industries should give the ceramic school appreciative support or they should advise discontinuance of the schools. These schools are supported by taxation. The ceramic industries pay their share of this support, hence their interest in the schools lies in both the cost and in the production of the schools.

There are many very capable collegiate trained technologists employed in ceramics who are not products of ceramic schools. There are very discerning managers of ceramic plants who have a preference for technical men other than graduates of ceramic schools and the service rendered has apparently justified this preference.

Facts are not disputable and the facts are that graduates of our ceramic schools have a justified demand for their services and this demand is increasing. The ceramic schools are serving a good purpose. They may not be giving the training most needed or which would be most effective but they certainly are fulfilling their purpose in the best way they know how. It is the duty of the industrialist to make known the manner in which the ceramic schools can more effectively serve the industries.

The service rendered by the ceramic schools is not the same as that rendered by the federal and state institutions. There is some overlapping but just enough to make solid and firm the whole American scheme of ceramic research and education. And this is true in the relations between the schools, the press and the associations. Each has its part and each has played its part.

This is the 30th Anniversary of the beginning of collegiate training in ceramic technology. This occasion should be of interest to every ceramist. This interest is national. No one school or organization is more interested than another and no association more than any other. THE AMERICAN CERAMIC SOCIETY, the national pooling of all technical ceramic interest, representing the industries, the schools, the federal and state organizations and the press, will give opportunity to fittingly celebrate this Anniversary the week of February 16. This will be an occasion for a frank exposé of our entire scheme for ceramic education and research.

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED FROM NOVEMBER 15 TO DECEMBER 15

Donald J. Andrews, 220 E. Second St., East Liverpool, Ohio. Secretary, The American Porcelain Co.

James M. Boyd, 16 Melbourne Road, Norwalk, Conn. Vice-President, Twiggs County Kaolin Co.

Marion K. Burr, 39 W. 9th Ave., Columbus, Ohio. Student.

G. Roger Coats, 610 Wesley Bldg., Philadelphia, Pa. Sales Engineer, F. J. Ryan & Co.

Frederick C. Henderson, 356 — 14th Ave., Columbus, Ohio. Student.

William L. Hurdman, 7 High St., Pensnett, Dudley, Worcestershire, England. Research Ceramic Chemist, Associated Enamelers, Ltd.

Charles L. Jones, Box 47, Swissvale, Pa. Chemical Engineer, Vesuvius Crucible Co.

F. A. McCann, Mellon Institute, Pittsburgh, Pa.

Cornelis J. van Nieuwenburg, RotterdamscheWeg, Delft, Holland. Professor in Analytical Chemistry of Delft Technical University.

Louis A. Snider, Box 604, Weirton, W. Va. Superintendent, Brick Masonry Department, Weirton Steel Co.

F. J. Sutphen, 2605 Central Ave., Middletown, Ohio. American Rolling Mill Co.

Society Boosters' Record

	Personal
Robert F. Ferguson	1
George A. Forbes	1
Robert E. Gould	1
R. D. Landrum	1
H. W. Mauser, Jr.	1
E. W. Tillotson	1
Office	5
Total	11

BALTIMORE-WASHINGTON SECTION MEETING

Thirty-two members and guests attended the meeting of the Baltimore-Washington Section held on November 22, 1924, at the Old Colony Club in the Emerson Hotel, Baltimore, Md. A dinner was served after which election of officers was held. The members elected to serve for the coming year are:

Herbert Insley, *Chairman*, Bur. of Standards, Washington, D. C.

Frank G. Roberts, *Vice-chairman*, Porcelain Enameling and Manufacturing Co., Baltimore, Md.

Reardon Fusselbaugh, *Secy. and Treas.*, Porcelain Enamel and Novelty Co., Baltimore, Md.

B. T. Sweely, *Councillor*, Baltimore Enamel and Novelty Co., Baltimore, Md.

An able and interesting paper on "Glass House Practice" by Clarence McComas of the Carr-Lowrey Glass Co. of Baltimore was presented. Mr. McComas went into the detail in explaining the use of the pot and continuous furnaces, the ills and remedies

of these two processes. Those of the members interested in glass expressed gratefulness for a wealth of information and a discussion of some few minutes ensued.

Stephen Leach, of the Locke Insulator Corporation, Baltimore, Md., gave an excellent paper on "China Clay." The section agreed that if there was anything about the formation, mining, preparation and uses of English china clay which were not touched upon by Mr. Leach, such things were unknown altogether. Mr. Leach was extended individual and collective appreciation for the interesting and thorough manner in which he dealt with his subject.

SOCIETY BOOSTERS FOR 1924

Olaf Andersen. Kristiania, Denmark. Member, AMERICAN CERAMIC SOCIETY, 1918—. Abstractor.

R. J. Anderson *Bull.*, **3** [1], 11. Abstractor.

ROBERT H. ARMSTRONG

R. H. Armstrong. Born Alfred, N. Y., 1900. B.S., Ceramic Engineering, Alfred Univ., 1922. Member, AMERICAN CERAMIC SOCIETY, 1923—. With Fiske and Co., Inc., summers of 1920 and 1921 and from 1922 to July, 1924. Present location, Alfred, N. Y. Contribution: "Some Unavoidable Heat Losses in the Use of Periodic Systems," *Journal*, June, p. 423.

Howard C. Arnold. B.S., Ceramics, Univ. of Illinois, 1914; M.A., 1916, Physical and Optical Mineralogy. Instructor, Ceramic Engineering, Univ. of Ill., 1916–17. First Lieut., Research Division, Chemical Warfare Service, U. S. A., 1917–19. Chief Chemist, B. F. Drakenfeld & Co., N. Y. City, 1919–21. Ceramic Engineer, Arthur D. Little Inc., Cambridge, Mass., 1921 to date. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Comm. on Education, Enamel Division.

George Aurien. Supt., Mississippi Glass Co. Member, AMERICAN CERAMIC SOCIETY, 1921—. Office: Comm. on Standards (Tests, Glass Division).

E. E. Ayars. *Bull.*, **3** [3], 100. Office: Editor, Question Box, Refractories Division. Contribution: "Firing Resistance in a Round, Down-draft Kiln Equipped with a Mechanical Stoker," *Journal*, December, p. 889.

Richard F. Bach. Formerly curator, instructor and executive secretary, Columbia University, School of Architecture. Taught history of architecture ornament, decorative arts, painting and sculpture. Library Avery Architectural Library. Associate Editor of *Good Furniture Magazine*. Regular contributor to art magazines, trade journals, year books. Since 1919 Extension Secretary of the American Foundation of Arts. Since 1918, Associate in Industrial Arts, Metropolitan Museum of Art. Contribution: "Art in Industry," *Bulletin*, August, p. 277.

Arthur E. Baggs. *Bull.*, **3** [1], 13. Office: Comm. on Rules, Art Division; Comm. on Divisions and Sections; Chairman, New England Section.

C. E. Bales. *Bull.*, **3** [1], 13. Office: Abstractor. Vice-chairman, Refractories Division.

L. E. Barringer. *Jour.*, **6** [1], 41. Office: Comm. on Publications; Associate Editor, *Journal;* Comm. on Education, Whitewares Division.

NOTE: Where pictures and biographical sketches of contributors to the *Journal* and workers for the SOCIETY have been published previously, a reference is made to this sketch followed by the contribution made in 1924.

G. E. Barton. *Bull.*, **3** [4], 131. Office: Chairman, Glass Division; Comm. on Divisions and Sections.

F. E. Bausch. *Bull.*, **3** [1], 13. Office: Chairman, St. Louis Section.

H. C. Beasley. Gen. Supt., Coonley Mfg. Co., Cicero, Ill. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Councillor, Enamel Division. Chairman, Chicago Section. Comm. on Divisions and Sections.

M. F. Beecher. Born, Mason City, Ia., April, 1887. B.S., Ceramics, 1910; Cer. Engineering, 1915, Iowa State College. Experience in stoneware plant and brick yard, Iowa Engineering Expt. Station. Research Laboratories, Norton Company, Worcester, Mass. Member, AMERICAN CERAMIC SOCIETY, 1910—. Offices: Trustee, one term. For 1924: Comm. on Papers and Definitions, Refractories Division. Comm. on Standards (Definitions). Directed publication of laboratory paper from Norton Co., "Studies on the Thermal Conductivities of Some Refractory Materials," *Journal*, January, p. 19.

LEO A. BEHRENDT

Leo A. Behrendt. Born, Chicago, Ill., May, 1894. Short course in ceramics, Univ. of Ill. Laboratory Assistant, Midland Terra Cotta Co., 1911–22. Supervised, mining and shipping of clay and coal, Chicago Terra Cotta Companies, 1922–24. Maintenance engineer and supervisor over raw materials, Midland Terra Cotta Co., 1924 to date. Member, AMERICAN CERAMIC SOCIETY, 1916—. Contribution: "Mining of Indiana Clay for Terra Cotta," *Bulletin*, September, p. 331.

E. C. BINGHAM

M. L. Bell. *Bull.*, **3** [1], 14. Office: Comm. on Research, Refractories Division.

Eugene C. Bingham. Born, Cornwall, Vt., December, 1878. A.B. degree, Middlebury College, 1899. Ph.D., Johns Hopkins Univ., 1905. Student Leipzig, Berlin and Cambridge (England), 1906. Member: American Chemical Society, A. S. T. M., A. A. A. S., Metric Assn., Amer. Assn. of Univ. Professors. Prof., Chemistry, Richmond College, 1906–15. U. S. Bureau of Standards, 1915–16. Lafayette College, 1916 to date. Contributions: "Plasticity as a Means for Control of Properties," *Journal*, June, p. 430. "Discussion on Plasticity," *Bulletin*, October, p. 375.

MARION W. BLAIR

C. F. Binns. *Jour.*, **6** [1], 23. Office: Comm. on Standards (Tests) Art Division.

Marion Worthington Blair. Born Brazil, Ind., 1878. Rose Polytechnic Inst., 1903. M.E. degree, Rose Polytech., 1913. Construction engineer and assistant superintendent, Terre Haute Vitrified Brick Co., 1903–05. Plant construction and general consulting work, also in charge technical bureau National Paving

Brick Mfrs. Assn., including investigation and standardization of Rattler Test for Paving Brick, specifs. for which are used through the U. S. and England, 1905–11. Design, construction and operation of plants manufacturing paving brick, face brick and hollow ware. Also developed complete system of method and process for manufacture of promenade and quarry tile (*Trans. Amer. Ceram. Soc.*, **19,** 361(1917)). Supt. in charge of operation and construction, Murphysboro Paving Brick Co., and H. & R. Mining and Mfg. Co. Work included complete electrification of Murphysboro plant and construction of a modern plant at East St. Louis, 1921–24. Engineer in charge of St. Louis territory for Manufacturers' Equipment Co., Dayton, Ohio, 1924 to date. Member, AMERICAN CERAMIC SOCIETY, 1914—. Contribution: "Elimination of Waste in Heavy Clay Products Industry," *Bulletin*, February, p. 56.

H. H. Blau. Born, Dayton, Ohio, May, 1897. B.S., Chem. Eng., Carnegie Inst. Tech., 1919. S.M. Physical Chemistry, Mass. Inst. Tech., 1920. Computer for Miami Conservancy District, Dayton, Ohio, 1917. Macbeth-Evans Co., Charleroi, Pa., 1920 to date. Contribution: "Note on Early Optical Glass Making in the U. S.," *Journal*, May, p. 322.

A. V. Bleininger. *Jour.*, **6** [1], 24. Office: Comm. on Divisions and Sections; Comm. on Research.

C. A. Bloomfield. *Jour.*, **5** [7], 66; *Jour.*, **6** [1], 87. Councillor, Eastern (New Jersey) Section.

George A. Bole. *Jour.*, **5** [11], 333; *Jour.*, **6** [1], 154. Office: Comm. on Contact, Heavy Clay Products Division; Comm. on Standards (Tests), Refractories Division. Contributions: Co-author with F. G. Jackson, "The Oxidation of Ceramic Ware during Firing. I. Some Reactions of a Well-Known Fire Clay," *Journal*, March, p. 163. Co-author with R. T. Stull, "Utilization of Georgia Kaolins in the Manufacture of Face Brick," *Journal*, May, p. 347.

M. C. BOOZE

Macdonald C. Booze. Born, Bethany, Ill., December, 1892. B.S., Ceramics, Univ. of Illinois, 1915. Supt., Medal Paving Brick Co., Wooster, Ohio, 1915–17. Ceramic Engineer, U. S. Bur. Mines, Ceramic Expt. Station, Columbus, Ohio, 1917–19. In charge of Ceramic Division, Research Laboratories, Norton Co., Worcester, Mass., 1919–23. Senior Fellow, Refractories Manufacturers Assn. Fellowship, 1923 to date. Member, AMERICAN CERAMIC SOCIETY, 1916—. Office: Comm. on Standards (Raw Materials), Refractories Division. Comm. on Coöperation. Representative Comm. E-1 A. S. T. M. Contributions: Co-author with F. C. Flint, "Checker Brick for Resisting Alkali Slags," *Journal*, August, p. 594. "Fire Clay Brick for the Open Hearth," *Journal*, September, 686.

N. L. BOWEN

J. C. Boudreau. *Bull.*, **3** [1], 14. Office: Comm. on Education, Art Division.

Norman L. Bowen. Born, Kingston, Ont., June, 1887. M.A., Queen's Univ., 1907; B.S., Queen's, 1909; Ph.D., Mass. Inst. Tech., 1912. Geological field work for Ontario Bur. Mines and Geol. Surv. of Canada, 1907–12. Petrologist, Geophysical Labora-

tory, 1917–18. Optical Glass Investigation, 1917–18. Prof. of Mineralogy, Queen's Univ., 1918–20. Petrologist, Geophysical Lab., 1920 to date. Member, Geol. Soc. Amer., Wash. Acad. Sci., Amer. Acad. Arts and Sci., Amer. Geophys. Union. Contribution: Co-author with J. W. Greig, "The System Al_2O_3–SiO_2," *Journal*, April, p. 238.

Davis Brown. Born, near Portland, Ind., August, 1860. Normal and night school for drawing and designing. Experience as machinist, sales engineer, shop supt., designing and manufacturing clay working machinery for the past thirty-five years. Now chief engineer, The Hadfield-Penfield Steel Co., Bucyrus, Ohio. Member, AMERICAN CERAMIC SOCIETY, 1918—. A.S.M.E. Contribution: "Combating Laminations and Improving the Brick Structure," *Journal*, April, p. 174.

DAVIS BROWN

R. P. BROWN

G. H. Brown. *Jour.*, **5** [7], 63; *Jour.*, **6** [1], 41. Secretary, Eastern (New Jersey) Section.

Richard P. Brown. Born, Philadelphia, Pa., September, 1884. Penn Charter School and Drexel Inst. Member, AMERICAN CERAMIC SOCIETY, 1915—. Also A.S.M.E., A.I.E.E., A.S.T.M., Amer. Electrochem. Soc., A.I.M.M.E. President, Brown Instrument Co., Philadelphia, Pa. Contribution: "Pyrometry—Past and Present," *Journal*, August, p. 620.

W. F. Brown. *Bull.*, **3** [1], 15. Office: Comm. on Standards (Tests), Glass Division.

W. K. Brownlee. Born, Wellsburgh, W. Va., 1867. Early experience in brick yards, glass furnace and glass factory construction, the latter with Nichols and Mathews. Supt. of furnace and construction work, Libbey Glass Co., Toledo, Ohio, 1900. Founded Buckeye Clay Pot Co., 1909. President and General Mgr. of this Company. President, Farber Fire Brick Co., Farber, Mo. Has been instrumental in developing continuous railroad tunnel kilns for fire brick to a high degree of economy and efficiency. Member, AMERICAN CERAMIC SOCIETY, 1921—. Contribution: "Insulation of Glass Tanks," *Journal*, June, 457.

W. K. BROWNLEE

JOHN F. BYRNE

P. P. Budnikoff. *Bull.*, **3** [1], 15. Contribution: "Comparison of Methods of Analysis of Gypsum," *Journal*, November, p. 817.

E. N. Bunting. *Bull.*, **3** [1], 16. Abstractor.

G. K. Burgess. *Jour.*, **6** [6], 191. Office: Councillor, Heavy Clay Products Division.

John F. Byrne. Born, Chicago, Ill., 1899. Univ. of Pittsburgh. B.S., Metallurgy, Univ. of Utah, M.S.,

MARGARET K. CABLE

Carnegie Inst. Tech. American Smelting and Refining Co., Garfield, Utah. Research Fellow, Carnegie Inst. Tech. Research on coal problems, U. S. Bureau of Mines, Pittsburgh Expt. Station, 1922 to date. Member, Amer. Chem. Soc. Contribution: Co-author with J. D. Davis, "An Adiabatic Method of Studying Spontaneous Heating of Coal," *Journal*, November, p. 809.

Margaret K. Cable. Born, Crookston, Minn. Worked in pottery at Handicraft Guild, Minneapolis. Studied with F. H. Rhead at St. Louis School of Ceramics, 1911. Later with Prof. C. F. Binns, Alfred Univ. Since 1910, Instructor in Ceramics, Univ. of N. Dak., Grand Forks, N. D. Made Asst. Prof. of Ceramics in School of Mines of Univ. of N. D. Investigative work on the high grade pottery clays of N. Dak. Member: AMERICAN CERAMIC SOCIETY, 1913—. Office: Vice-chairman, Art Division. Contribution: "Glazes and Indian Designs on North Dakota Pottery," *Journal*. June, p. 489.

H. D. Callahan. Employed, Northwestern Terra Cotta Co., Chicago, Ill. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Comm. on Contact, Terra Cotta Division.

R. L. Clare. *Jour.*, **6** [1], 56. Office: Associate Editor, *Journal*. Trustee, Terra Cotta Division.

H. H. Clark. Born, Chicago, Illinois, July, 1885. M.E., Mo. School of Mines, 1905. Consulting engineer on problems connected with industrial fuels and furnaces. Member, AMERICAN CERAMIC SOCIETY, 1921—. Contribution: "Gas as a Fuel for Vitreous Enameling," *Journal*, August, p. 643.

W. M. Clark. *Jour.*, **6** [6], 58. Abstractor. Office: Chairman, Comm. on Research, Glass Division.

HORACE H. CLARK

Willi M. Cohn. Born, Berlin, June, 1897. Technische Hochschule, Danzig. Technische Hoch., Berlin. Dipl. Ingenieur. Dr. Ing. Managing director, the Kishon Clay Works, Ltd., Haifa, Palestine. Member, Verein Deutscher Ing., German Ceramic Society. Contribution: "The Problem of Heat Economy in the Ceramic Industry," *Journal*, May, p. 359; June, p. 475; July, p. 548.

S. S. COLE

Sandford S. Cole. Born, Cuba, N. Y., 1900. B.S., Ceramics, Alfred Univ., 1923. Industrial Fellow, Mellon Inst. with Koppers Co., in charge of research on silica and clay refractories and standardization of the same for use in coke and gas oven construction. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Abstractor.

Raymond D. Cooke. Born, Fond du Lac, Wis., December, 1890. B.S. (Chemistry), Univ. of Wis., 1913. M.S., Univ. of Wis., 1914. Chemist, Armour & Co., Chicago, 1914–17. Fellow Mellon Inst., Enameling

Fellowship, 1917–23. Supt., Enamel Dept., Columbian Enameling and Stamping Co., Terre Haute, Ind., 1913 to date. Member, AMERICAN CERAMIC SOCIETY, 1917—. Office: Representative, Comm. on Nominations, Enamel Division. Comm. on Papers and Program. Editor, Question Box. Comm. on Standards (Tests). Coöperative Comm. on Fish-Scale Research. Contributions: "The Effect of Furnace Atmosphere on the Firing of Enamel," *Journal*, April, p. 277. "The Plastic Properties of Enamel Slip," *Journal*, September, p. 651.

R. D. COOKE

Sidney Cornell. Born, Derby, Conn., October, 1887. Stevens Inst. of Tech. Prof. Engineer, Univ. State of N. Y. Carnegie Steel Co., Duquesne Works Laboratory. Technical Assistant and Lubricant Inspector, 1907–12. As Secy., Pittsburgh Section, Amer. Electrochem. Soc. made trip to Europe on elec. furnaces, 1912. Efficiency Eng., Pittsburgh Crucible Steel Co., 1913. Chem. Engr., Griscom Russell Co., 1914. Efficiency Engr. and Supt. of Heat Treating, Remington Arts UMC Co., 1914–17. Captain Ordnance, U. S. A., 1917–19. Consulting Chem. and Indus. Mgr., 1919—. Contribution: "Some Considerations Necessary in Selection of Refractories for the Open Hearth," *Journal*, September, p. 670.

SIDNEY CORNELL

Paul E. Cox. *Jour.*, **6** [1], 105. Office: Comm. on Research, Art Division. Comm. on Papers and Program. Contributions: "A Study of Plasticity by Practical Potters' Methods," *Journal*, March, p. 151. "A Ceramic Decorative Process Suitable for Public School Use," *Journal*, July, p. 511.

Charles W. Crane. *Bull.*, **3** [1], 16. Office: Chairman, Eastern (New Jersey) Section. Comm. on Divisions and Sections.

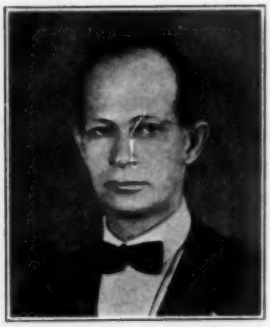
J. L. Crawford. *Bull.*, **3** [1], 17. Office: Comm. on Coöperation, Refractories Division.

J. W. Cruikshank. Born, London, England. Consulting Engr., 1901–17, design and construction of glass factories. Work for foreign plate glass mfgrs. Captain, U. S. Engrs. during World War. Incorporated J. W. Cruikshank Engineering Co., 1917. Member, Engrs. Soc. W. Pa., Soc. Amer. Military Engrs., Soc. Glass Tech. (English). AMERICAN CERAMIC SOCIETY, 1920–24. Corporation member, 1924—. Office: Chairman, Pittsburgh Section. Comm. on Divisions and Sections, Glass Division.

J. W. CRUIKSHANK

T. S. Curtis. Pres. Vitrefrax Co., Los Angeles, Calif. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Secretary, California Section.

R. R. Danielson. *Jour.*, **6** [1], 52. Offices: Chairman and Trustee, Enamel Division. Comm. on Research. Comm. on Divisions and Sections. Associate Editor, *Journal*. Abstractor. Contributions: Co-author with T. D. Hartshorn and W. N. Harrison, "Factors Affecting the Warpage of Sheet Iron and Steel in Enameling," *Journal*, May, p. 326.



J. D. DAVIS

J. D. Davis. Born, Middleport, Ohio, April, 1882. B.A., Ohio State Univ., 1905. Grad. work in George Washington Univ. and Univ. of Pittsburgh. Chemist, Columbus Iron and Steel Co. (6 months). Chemist, Lowe Bros. Paint Co., Dayton, Ohio (2 years). Chemist, U. S. Geol. Surv., Washington, D. C. (2 years). Chemist, U. S. Bur. Mines (14 years). Fuel chemist, U. S. Bur. Mines, Pittsburgh Expt. Sta. to date. Member: Amer. Chem. Soc., A. S. T. M., Amer. Gas Assn. Contribution: Co-author with J. F. Byrne, "An Adiabatic Method of Studying Spontaneous Heating of Coal," *Journal*, November, p. 809.

H. L. Dixon. President and Gen. Mgr., H. L. Dixon Co., Pittsburgh, Pa. Member, AMERICAN CERAMIC SOCIETY, 1919—. Contribution: "What is the Effect of Selenium Decolorizer on Tank Blocks?" *Bulletin*, September, p. 332.

W. E. Dornbach.[1] Born, McGregor, Iowa, 1889. B.S., Ceramic Engineering, Iowa State College, 1911. Worked with Amer. Brick and Tile Co., Mason City, Ia. Morey Clay Products Co., Ottumwa, Ia. Southern Clay Mfg. Co., Warrior, Ala. Warrior and Robbins (Tenn. Plants). Auburn Shale Brick Co., Auburn, Pa. Amer. Refrac. Co., Magnesite and Chrome Brick Plant, Baltimore, Md. General Refractories Co. (main office), Philadelphia, Pa. to date. District Chief, Indus. Fur. Sec., U. S. Fuel Administration during World War. Member, AMERICAN CERAMIC SOCIETY, 1911—. Offices: Chairman, Membership Comm., Refractories Division, 1922. Refractories Div., representative on Comm. C-8, A. S. T. M., 1923. Comm., Sections and Divisions. Comm. on Publications (*Journal*).

Conrad Dressler. *Bull.*, **3** [1], 18. Office: Comm. on Data.

E. V. Eskesen. *Bull.*, **2** [7], 235. Contribution: "The Investigation of Terra Cotta Work at the Bureau of Standards," *Bulletin*, May, p. 158.

George P. Fackt. *Bull.*, **3** [1], 18. Office. Councillor, Terra Cotta Division.

R. F. Ferguson. *Bull.*, **3** [1], 19. Office: Secretary, Refractories Division. Editor, Clay Refractories Bibliography.

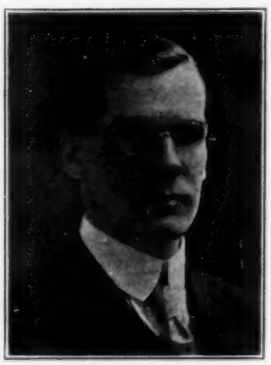
A. N. Finn. *Bull.*, **3** [4], 132. Offices: Secretary, Glass Division. Chairman, Comm. on Standards (Tests). Comm. on Papers and Program.

F. C. Flint. *Bull.*, **3** [1], 19. Office: Councillor, Glass Division. Contribution: Co-author with M. C. Booze, "Checker Brick for Resisting Alkaline Slags," *Journal*, August, p. 594. Abstractor.

H. D. Foster. *Bull.*, **3** [1], 20. Contribution: "Strength, Absorption and Freezing Resistance of Hollow Building Tile," *Journal*, March, p. 189. Abstractor.

Sidney L. Galpin. Born, Jefferson, Ohio, 1886. A.B., Western Reserve Univ., 1907. A.M., 1910. Ph.D., Cornell Univ., 1912. Two years geological work on feldspar, etc. Consulting work on clay, petroleum and coal properties. Teaching of geology for fifteen years. Associate Prof. Geology, Iowa State College, Ames, Iowa. Member, AMERICAN CERAMIC SOCIETY, 1911—. Office: Chairman, Comm. on Geological Surveys.

W. D. Gates. *Jour.*, **6** [1], 26. Office: Chairman, Terra Cotta Division. Comm. on Divisions and Sections.



S. L. GALPIN

[1] See page 29 for photograph.

J. W. Gayner. Born, Caven's Point, N. J. General Manager, Lynchburg Glass Corporation, Lynchburgh, Va. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "How to Get Rid of Scum on a Tank Melting Flint Bottle Glass," *Journal*, March, p. 200.

C. F. Geiger. *Bull.*, **3** [1], 21. Office: Comm. on Standards (Products). Comm. on Papers and Program, Refractories Division.

S. Geijsbeek. *Jour.*, **6** [1], 26. Office: Councillor and Treasurer, Pacific-Northwest Sec.

R. F. Geller. *Bull.*, **3** [1], 21. Office: Chairman, Comm. on Standards. Comm. on Papers and Program, Refractories Division. Contribution: "The Laboratory Testing of Aluminous Refractories," *Journal*, September, p. 663.

Albert C. Gerber. Born, Toledo, Ohio, January, 1893. B.S., Ceramic Eng., Ohio State Univ., 1915. Ceramic Engr., Green Eng. Co., East Chicago, Ind. Staff of H. Koppers Co., Pittsburgh, Pa., 1916. U. S. Army during World War. Ceramic Eng., Trenton Fire Clay and Porcelain Co. Ceramic Eng., Electric Porcelain and Mfg. Co., Trenton, N. J. to date. Member, AMERICAN CERAMIC SOCIETY, 1923—. Contribution: "The Use of Gelatine in Glaze Application," *Journal*, June, p. 494.

ALBERT C. GERBER

L. E. GEYER

Leon E. Geyer. Chief Clerk, U. S. Bur. Mines, Ceramic Expt. Station, Columbus, Ohio. Advertising Manager, *Journal*.

H. W. Gillette. Born, N. Y. State, December, 1883. A.B. and Ph.D., Cornell Univ. Chemist with Thomas A. Edison, A. D. Little, Inc., Aluminum Castings Co., U. S. Bur. Mines (12 years). Chief Director of Metallurgy, Bur. Standards, Washington, D. C. to date. Contribution: Co-author with E. L. Mack, "The Electric Brass Furnace Situation," *Journal*, April, p. 288.

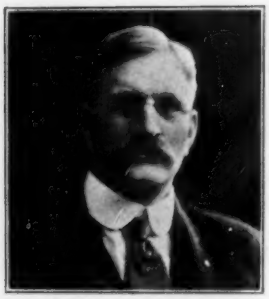
James Gillinder. Born, Philadelphia, Pa., 1880. B.S., Chemistry, Univ. of Penna. Instructor, Univ. of Pa., 1900–02. Manager, Gillinder & Sons, Inc., Philadelphia. Supt. Gillinder Brothers, Inc., Port Jervis, N. Y., 1912 to date. Member, AMERICAN CERAMIC SOCIETY, 1918—. Office: Comm. on Research, Glass Division.

JAMES GILLINDER

A. F. Gorton. *Jour.* **6** [1], 69. Abstractor.

A. F. Greaves-Walker. *Jour.*, **6** [1], 44; *Bull.*, **3** [9], 356. Office: Trustee. Associate Editor, *Journal*.

M. E. Gregory. Born, Caton, N. Y., July, 1864. Graduate, Corning Free Academy, 1886. Taught school, N. J. (4 years). Entered terra cotta business, 1890. Bought business, 1896. Mfg. paving brick, face brick, and architectural terra cotta until Jan. 1, 1924. Manuf. only architectural terra cotta to date. Company name, "Corning Terra Cotta Company." Member, AMERICAN CERAMIC SOCIETY, 1917—. Ex-



M. E. GREGORY

Pres., M. B. M. A. and N. Y. State Builders' Assn. Office: Councillor, Terra Cotta Division.

J. W. Greig. Born, Wingham, Ontario, 1895. B.S., Queen's Univ. Petrologist, Geophysical Laboratory. Co-author with N. L. Bowen, "The System Al_2O_3–SiO_2," *Journal*, April, p. 238.

R. E. Griffith. Manager, Refractories Sales, E. J. Lavino & Co., Philadelphia, Pa. Member, AMERICAN CERAMIC SOCIETY, 1920—. Contribution: "Chrome Refractories for the Open Hearth," *Journal*, September, p. 690.

J. W. GREIG

F. F. Grout. Born, Rockford, Ill., January, 1880. B.S., Univ. of Minn., 1904. Ph.D., Yale, 1916. Teaching and geol. surveys, 1904–1924. Prof. of Geol. and Mineralogy, Univ. of Minn. Contribution: "The Relation of Texture and Composition of Clays," *Journal*, February, p. 122.

F. F. GROUT

Julius Grunwald.[1] *Bull.*, **3** [6], 235. Contribution: "European Practice in the Manufacture of Enameled Cast Iron Ware," *Journal*, February, p. 118.

V. K. Haldeman. Born Morrill, Kans., March, 1899. B. S., Univ. of Ill., 1924. Ceramic Engineer, Beaver Falls Art Tile Co., Beaver Falls, Pa. Member, AMERICAN CERAMIC SOCIETY, 1924—. Contribution: "Aventurine Glazes," *Journal*, October, p. 824.

Abel Hansen. Born, Copenhagen, Denmark, August, 1863. Copenhagen High School, 1879. Danish Army, 3 years. Learned manufacture and baking of clay, Esberg, Denmark, 9 years. Located at Perth Amboy, N. J. Perth Amboy Terra Cotta Co. (2 years). Standard Terra Cotta Works (16 years). Established Fords Porcelain Works, sole owner, 1906. President, New Jersey Clayworkers Assn. Member: AMERICAN CERAMIC SOCIETY, 1908—. Office: Chairman, Standing Comm. on Membership.

ABEL HANSEN

J. E. Hansen. Born, Fowler, Ind., 1898. B.S., Univ. of Ill., 1920. Chemist, Enameling Plant of Benjamin Electric Co., Des Plaines, Ill., 1918. Since 1920 to date, Industrial Fellow, Mellon Institute, research and plant development work on vitreous enamels for the Stove Founder's Research Association. Member AMERICAN CERAMIC SOCIETY, 1920—. Office: Comm. on Data, Enamel Division. Comm. on Membership. Contribution: "Discussion on Charles

[1] Deceased.

Musiol's paper, "Exact Notions of Fluorine Enamels," *Journal*, February, p. 115.

Harold C. Harrison. Born, Columbus, Ohio, November, 1899. B.S. Metallurgical Engineering, Ohio State Univ., 1922. B.S. Mechanical Eng., Ohio State Univ., 1923. U. S. Bureau of Mines, Ceramic Expt. Station, Columbus, Ohio, on coöperative work with McLanahan and Watkins Co. Member, AMERICAN CERAMIC SOCIETY, 1923—. Contribution: "Roof Brick for the Open Hearth," *Journal*, September, p. 698.

HAROLD C. HARRISON

William N. Harrison. Born, Tunstall, Va. B.S., Chemistry, Virginia Polytechnic Inst. in 1920. M.S., Univ. of Chicago, 1921. Enameled Metals Section, U. S. Bur. Standards, Washington, D. C., 1922 to date. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Comm. on Standards (Tests), Enamel Division. Contributions: Co-author with R. R. Danielson and T. D. Hartshorn, "Factors Affecting the Warpage of Sheet Iron and Steel in Enameling," *Journal*, May., p. 326. Co-author with H. G. Wolfram, "The Development of Jewelry Enamels," *Journal*, December, p. 857.

J. E. HANSEN

T. D. Hartshorn. *Bull.*, **3** [1], 23. Contribution: Co-author with R. R. Danielson and W. N. Harrison, "Factors Affecting the Warpage of Sheet Iron and Steel in Enameling," *Journal*, May, p. 326.

F. A. Harvey. *Jour.*, **6** [1], 55. Office: Chairman, Refractories Division. Comm. on Divisions and Sections. Contributions: "Notes on Secondary Expansion of Flint Clay," *Journal*, June, p. 455. Co-author with E. N. McGee, "Factors Affecting the Resistance of Silica Refractories to Abrasion," *Journal*, December, p. 895.

W. N. HARRISON

George H. Hays. Assistant Mgr., Vitreous Enameling Co., Cleveland, Ohio. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Secretary, Northern Ohio Section.

E. L. HETTINGER

Perry D. Helser. *Bull.*, **3** [1], 24. Abstractor.

H. B. Henderson. *Bull.*, **3** [3], 99. Office: Treasurer.

A. V. Henry. *Bull.*, **3** [1], 45. Office: Comm. on Standards (Products), Heavy Clay Products Division. Contribution: "The Electrical Resistivity of Refractories," *Journal*, October, p. 764.

J. W. Hepplewhite. *Jour.*, **6** [1], 60. Office: Comm. on Membership, Refractories Division.

H. W. Hess. *Bull.*, **3** [1], 25. Office: Representative, Comm. on Nominations, Glass Division.

E. L. Hettinger. Born, near Reading, Pa., 1879. Interstate Commercial College and Alexander Hamilton Institute. Penn

sylvania Optical Co., 1898. Assistant Secy. and Purchasing Agent, Willson Goggles, Inc., Reading, Pa., to date. Contribution: "The Development of Transparent Colored Glass in America for Goggle Purposes," *Journal*, May, p. 318.

L. C. Hewitt. *Bull.*, **3** [1], 25. Offices: Chairman, Comm. on Papers and Program, Refractories Division. Secretary, St. Louis Section.

C. W. Hill. *Bull.*, **3** [1], 25. Offices: Rep. Comm. on Nominations. Comm. on Standards (Tests and Products), Terra Cotta Division.

E. C. Hill. *Bull.*, **3** [1], 25. Offices: Comm. on Research, Terra Cotta Division. Comm. on Standards (Raw Materials).

Roy Horning. *Bull.*, **3** [1], 26. Office: Associate Editor, *Journal*.

J. C. Hostetter. *Jour.*, **6** [1], 54. Offices: Trustee, Glass Division. Comm. on Data.

A. F. Hottinger. *Jour.*, **5** [9], 204; *Jour.*, **6** [1], 46. Office: Comm. on Education, Terra Cotta Division.

F. T. Houlahan. President, Builders Brick Co. Member, AMERICAN CERAMIC SOCIETY, 1924. Secretary, Pacific Northwest Section.

H. E. HOWE

Harrison Estell Howe. Born, Georgetown, Ky., December, 1881. B.S., Earlham College, 1901. Graduate Work, Univ. of Mich., 1901–02. M.S., Univ. of Rochester, 1913. Chemist, Sanilac Sugar Refining Co., 1902–04. Bausch & Lomb Optical Co., various capacities including chief chemist, 1904–15. Arthur D. Little, Ltd., 1916–19. Consulting Chemist, Nitrate Division, Army Ordnance, 1918. Chairman, Division of Research Extension, National Research Council, 1919 to Dec., 1921. Editor, *Industrial and Engineering Chemistry*, 1921 to date. Member, Amer. Chem. Soc., Amer. Electrochem. Soc., A. I. C. E., Soc. of Chem. Industry, Amer. Oil Chemists' Soc., A. A. A. S., Amer. Eng. Council. Contribution: "Scientific Research as an Association Activity," *Bulletin*, June, p. 209.

Raymond M. Howe.[1] *Jour.*, **6** [1], 45, *Bull.*, **3** [5], 169. Office: Vice-president.

Addis E. Hull, Jr. Assistant to General Mgr., A. E. Pottery Co., Crooksville, Ohio. Member, AMERICAN CERAMIC SOCIETY, 1923—. Contribution: "One Fire Whiteware through Direct Fired Car Tunnel Kiln," *Journal*, April, p., 285.

Herbert Insley, Jr. *Bull.*, **3** [1], 26. Offices: Comm. on Papers and Program, Glass Division. Secretary, Baltimore-Washington Section. Contribution: "The Microscopic Identification of Stones in Glass," *Journal*, January, p. 14. "Notes on the Behavior of Glass Melting Furnaces," *Journal*, August, p. 583.

FREDERICK GRAY JACKSON

Frederick G. Jackson. Born, Beverly, Mass., August, 1881. A.B., Harvard College, 1903. S.M., Harvard Grad. School. Germany, studied under Prof. Haber, one year. Alfred Univ., summer, 1924. University teaching, 3 years. National Carbon Co., Illinois Steel Co., Commercial Chemical Co. Lieut. Naval Reserve, Chemist Submarine Base, New London, Conn. Chemist, U. S. Bur. Mines, Ceramic Expt. Station, 1921 to date. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Chairman, Comm. on Research, Heavy Clay Products Division. Contribu-

[1] Deceased.

tions: "The Oxidation of Ceramic Wares during Firing. II. The Decomposition of Various Compounds of Iron with Sulphur under Simulated Kiln Conditions," *Journal*, April, p. 223, May, p. 382. III. "The Behavior of Calcium Compounds in Clays," June, p. 427. IV. "The Absorption of Sulphur Gases by Ferric Oxide in Clay," July, p. 532. V. "A Quantitative Study of the Nature of Sulphur Evolution in Kiln Firing," August, p. 634, September, p. 656. Co-author with G. A. Bole, I. "Some Reactions of a Well Known Fire Clay," March, p. 163.

J. T. JANS

John T. Jans. Born, Lemars, Iowa, October, 1890. B.E., Univ. of Iowa, Applied Science, 1912. C.E., Civil, Mech. Engineering and Combustion Engineering, 1919. Design and field work on construction, 1917. Captain, U. S. Army Engineers, France, 1917–19. Holcroft and Co., design, construction and service furnace and kiln work, 1919 to date. Contribution: "Operation Data on Continuous Kiln at Mt. Clemens Pottery Co.," *Journal*, August, p. 626.

ROBT W. JONES

J. A. Jeffery. President, Champion Porcelain Co., Detroit, Mich. Member, AMERICAN CERAMIC SOCIETY. Contribution: "Coördinating Research and Technical Information with Plant Control," *Bulletin*, May, p. 141.

Robert W. Jones. Born, Catskill, N. Y., April, 1882. Educated as mining engineer with special work in geology. Assistant Economic Geologist, N. Y. State Museum, 1912–20. Non-professional work, mining engineer, gold, silver and copper mines, western U. S., Central and South America, 1905–12. Member, AMERICAN CERAMIC SOCIETY, 1916 to date. Office: Comm. on Geological Surveys.

W. R. Kerr. Mellon Institute, Pittsburgh, Pa. Abstractor.

Pierce W. Ketchum. Ceramics Department, Univ. of Illinois, Urbana, Ill. Abstractor.

Herbert S. Kirk. *Jour.*, **6** [1], 52. Office: Secretary, Art Division. Representative, Comm. on Nominations.

A. A. Klein. *Bull.*, **3** [1], 27. Office: Chairman, Comm. on Education, Refractories Division. Comm. on Research. Councillor, New England Section.

T. A. Klinefelter. *Jour.*, **6** [1], 59. Contribution: "Clay Preparation," *Journal*, July, p. 509.

Seiji Kondo. Tokyo Higher Technical School, Asakusa, Tokyo, Japan. Member AMERICAN CERAMIC SOCIETY, 1916—. Abstractor.

Hobart M. Kraner. Born, Columbus, Ohio, November, 1896. B.S., Ceramic Eng., Ohio State Univ., 1921. M.S., Ohio State Univ., 1922. U. S. Bur. Mines, Ceramic Expt. Sta., Columbus Ohio, 1918–19, 1922–23. A. C. Spark Plug Co., April 1923–Nov.

H. M. KRANER

J. S. LATHROP

1924. Illinois Electric Porcelain Co., Macomb, Ill., to date. Member, AMERICAN CERAMIC SOCIETY, 1919—. Contributions: "Sillimanite Development in Some Typical Clays," *Journal*, October, p. 726. "Colors in a Zinc Silicate Glaze," *Journal*, December, p. 868.

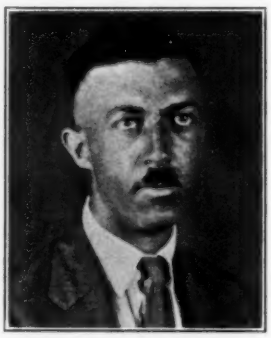
W. H. Landers. St. Louis Lithopone Co., Collinsville, Ill. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "Feldspar Milling," *Bulletin*, August, p. 300.

R. D. Landrum. *Jour.*, **6** [1], 47. Office: President. Councillor, Northern Ohio Section.

Karl Langenbeck. *Jour.*, **6** [1], 27. Contribution: "What Has Been the Experience in Substituting Domestic Secondary and Primary Kaolins for English China Clays," *Bulletin*, November, p. 417.

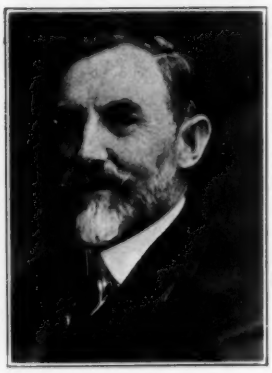
John S. Lathrop. Born, Chicago, Ill., 1897. B.S. degree, Univ. of Ill., Ceramic Engineering, 1922. Tropico Potteries Co., Glendale, Calif., 1922 to date. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: Co-author with C. W. Parmelee, "Aventurine Glazes," *Journal*, July, p. 567.

C. H. Lawson. *Bull.*, **3** [1], 28. Office: Secretary, New England Section.



R. D. LEITCH

R. D. Leitch. Born, Terre Haute, Ind., April, 1894, B.S. in Chem. Eng., Rose Polytechnic Inst., 1916. Ch. E., 1921. M.S., 1922. Research Chemist, U. S. Rubber Co., Naugatuck, Conn., 1916–17. Chief chemist, same Company, Mishawaka, Ind., 1917. Research chemist, E. I. du Pont de Nemours and Co., 1917–18, Arlington, N. J. 2nd Lieut. U. S. Engineers, 1918–19. Junior Explosives, Chem., U. S. Bur. of Mines, 1919–20. Vice-pres., The Cellulo Co., Inc., Sandusky, Ohio, 1920–21. Junior Gas Engr., Ill. State Geol. Survey and U. S. Bureau of Mines, Urbana, Ill., 1921–22. Asst. Fuel Engr., U. S. Bur. Mines, 1922–23, Oct. 1, 1924 (investigation of stream pollution and possible methods of control). Member, AMERICAN CERAMIC SOCIETY, 1924—. Amer. Inst. Chemists. Abstractor



W. N. LOGAN

J. T. Littleton, Jr. *Bull.*, **3** [1], 29. Office: Abstractor.

William Newton Logan. Born, Barboursville, Ky., 1869. A.B. and A.M., Univ. of Kans., Ph.D., Univ. of Chicago. Prof. Geol. and Mineralogy, St. Lawrence Univ. Dean, School of Sci. and Prof. of Geol., and Mining Eng., Mississippi Agricultural and Mechanical College. Prof., Econ. Geol., Indiana Univ., State Geologist to date. Member, A. A. A. S., Fellow, Geol. Soc. of Amer., Fellow, Royal Soc. Arts, Fellow, Indiana Acad. Sci. and Kans. Acad. Sci. Contribution: "Refractory Clays of Indiana," *Journal*, March, p. 201.

R. F. Lunger. Contribution: Co-author with R. A. Sherman and W. E. Rice, "The Significance of Drafts in Down-draft, Coal-fired Kilns," *Journal*, April, p. 255.

D. A. Lyon. *Jour.*, **6** [1], 153. Contribution: "Some Considerations of Selections of Refractories for the Open Hearth," *Journal*, September, p. 705.

Edward L. Mack. Born Vergennes, Vt., August, 1890. B.S., Union College, 1912. Ph.D., Cornell Univ., 1916. Chemist and Metallurgist, U. S. Bureau of Mines, 1916 to date. Contribution: Co-author with H. W. Gillette, "The Electric Brass Furnace Refractory Situation," *Journal*, April, p. 288.

Charles Maddock, Jr. Thomas Maddock Sons, Trenton, N. J. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Representative, Comm. on Nominations, Whitewares Division.

A. Malinovszky. *Bull.*, **3** [1], 29. Office: Comm. on Divisions and Sections. Chairman, California Section.

M. E. Manson. *Bull.*, **3** [1], 29. Office: Abstractor. Councillor, Enamel Division.

John D. Martin. *Bull.*, **3** [1], 30. Office: Vice-chairman, Heavy Clay Products Division. Contribution: "Further Development of an Automatic Kiln Stoker," *Journal*, December, p. 878.

Oscar E. Mathiasen. Elizabeth, N. J. Contribution: "The Effect of Uranium in Various Types of Glazes," *Journal*, July, p. 499.

Wm. R. Mattson. Born, Philadelphia, Pa., 1891. B.S., Civil Engineering, Mass. Inst. Tech., 1913. Construction engineering, highways and industrial buildings, 4 years. Captain, 101st Engineers, France (2 years). Economic Engineer, Babson Statistical Organization, Wellesley Hills, Mass. (5 years to date). Contribution: "Economic Factors that Make Research in Industry Important," *Bulletin*, May, p. 153.

W. R. MATTSON

F. R. McCannell. Milton Pressed Brick Co., Milton, Ont. Corporation representative, AMERICAN CERAMIC SOCIETY. Office: Comm. on Papers and Program, Heavy Clay Products Division.

G. V. McCauley. Physicist, Corning Glass Works, Corning, N. Y. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Comm. on Data.

J. Spotts McDowell. *Jour.*, **6** [1], 55. Office: Trustee, Refractories Division. Comm. on Standards (Definitions). Vice-chairman, Pittsburgh Section.

E. N. McGEE

Earle N. McGee. Born, Potsdam, N. Y., 1891. B.S., St. Lawrence Univ., 1912. Semet-Solvay and Solvay Process Co., 1916–18. In charge of Refractories Laboratory, same Company, Syracuse, N. Y., 1918 to date. Member, AMERICAN CERAMIC SOCIETY, 1921—. A. S. T. M. Office: Chairman, Comm. on Research, Refractories Division. Contribution: Co-author with F. A. Harvey, "Factors Affecting the Resistance of Silica Refractories to Abrasion," *Journal*, December, p. 895.

T. N. McVay. Born, Hawkins, Pa., February, 1891. B.S., Ceramic Eng., Univ. of Illinois, 1914. Refractory and Brick Plants, 1914–22. Instructor in Ceramic

GEORGE E. MERRITT

Eng., Univ. of Ill., 1922 to date. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Abstractor.

George E. Merritt. Born, Indianapolis, Ind., June, 1890. B.A., Pomona College, 1913. Graduate work, Univ. of Wis., Columbia Univ. U. S. Bur. Standards, Washington, D. C., work in optical instruments, ceramics and interference, index of refraction, thermal expansion and time change. Contribution: "Thermal Expansion of Fused Quartz," *Journal*, November, p. 803.

Gilbert F. Metz. Born, Omaha, Nebr., October, 1889. B.S., Mine Eng., School of Mines, Univ. of Mo., 1914. Eng. of Mines degree, 1919. Atlas Portland Cement Co., surveyor and draftsman, plant engineer, 1914–18. Engineer, Officer, Transport Duty, U. S. Navy, 1918–19. Division Sales Engineer, Engineer, Hardinge Co., Inc., 1919 to date. Member, AMERICAN CERAMIC SOCIETY, 1921—. A. I. M. M. E. Contribution, "Ceramic Raw Materials, Driers and Drying," *Journal*, July, p. 504.

L. R. Milford. Laboratory manager, The Solvay Process Co., Syracuse, N. Y. Member, AMERICAN CERAMIC SOCIETY, 1921—. Office: Comm. on Standards (Tests), Glass Division.

C. R. Minton. Los Angeles Pressed Brick Co., Los Angeles, Calif. Member, AMERICAN SOCIETY, 1920—. Contribution: "The Direct-Fired Car Tunnel Kiln on Roofing Tile," *Journal*, November, p. 821.

R. H. Minton. *Jour.*, **6** [1], 42. Office: Editor, Question Box, Terra Cotta Division.

C. H. Modes. Supt. of Furnaces, Illinois Glass Co., Alton, Ill. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "Longer Life of Our Tanks," *Bulletin*, June, p. 222.

R. J. Montgomery. *Bull.*, **3** [1], 30. Office: Comm. on Data, Glass Division. Office: Abstractor.

CHARLES MUSIOL

Charles Musiol. Born, Budejovice, Czechoslovakia, 1873. Degree, Mech. Eng., Brno, 1894. Manager, Enamel work, Kralovo, Pole, 1896. Technical director, enamelworks "Waulkan," Warsaw, Poland, 1896–1909. Engineering office, constructor and consulting engineer of stamping and enamelworks, Brussels, 1909. Has established six new enamelworks in Europe and one in Brazil. Made inventions in stamping, enameling and laboratory furnaces and enamels. (U. S. A. patent of boronless enamels.) Member, AMERICAN CERAMIC SOCIETY, 1918—. Contribution: "Exact Notions of Fluorine Enamels," *Journal*, February, p. 105.

C. L. NORTON

Louis Navias. *Bull.*, **3** [1], 31. Office: Abstractor.

Charles Ladd Norton. Born, Springfield, Mass., December, 1870. B.S., Mass. Inst. Tech., 1893. Teaching Industrial Physics, Mass. Inst. Tech., 1893 to date. Prof., Indus. Physics. Head of dept. of

Physics in charge of laboratories of Industrial Physics. Director, Division of Industrial Coöperation and Research, M. I. T. For a number of years, president, Asbestos Wood Co., Nashua, N. H. and Asbestos Shingle Co., New York. Member, AMERICAN CERAMIC SOCIETY, 1923—. A. S. M. E., A. S. T. M., Amer. Chem. Soc., Amer. Phys. Soc., Soc. for the Promotion of Eng. Education, Fellow, Amer. Acad. Arts and Sci., Contribution: "Massachusetts Institute of Technology Plan for Industrial Coöperation," *Bulletin*, July, p. 247.

Frederick Harwood Norton. Born, Manchester, Mass., October, 1896. B.S., Physics, Mass. Inst. Tech. Specialized in Aeronautics. Formerly chief physicist, National Advisory Comm. for Aeronautics. Babcock and Wilcox Fellow, Division of Industrial Research and Coöperation, Mass. Inst. Tech. Member, AMERICAN CERAMIC SOCIETY, 1923—. Soc. of Automotive Eng., Amer. Physical Soc. Contribution: "A Qualitative Laboratory Slag Test," *Journal*, August, p. 599; "The Design of Kilns and Furnaces from Mold Tests," *Journal*, October, p. 783.

F. H. NORTON

H. H. Norton. Lieut. Comdr., Fuel Oil Section Plant, Navy Yards, Philadelphia, Pa. Co-author with R. L. Porter, "The Method of Selecting Refractories for Marine Purposes of the Navy," *Journal*, July, p. 575.

MRS. O. P. R. OGILVIE

O. P. R. Ogilvie (Mrs.). Born, Ladonia, Texas, March, 1869. Librarian, Mines Branch, Department of Mines, Ottawa, Canada, 1913 to date. Office: Abstractor.

William Abbott Oldfather. Born, Urumiah, Persia, October, 1880. A.B., Hanover College, 1899. Harvard Univ., 1901, A.M., 1902. Ph.D., Munich, 1908. Instructor and Asst. Prof., Northwestern Univ., 1903–06; 1908–09. Assoc. Prof. and Prof. of Classics, 1909 to date. Contributor to Report of Comm. on Definition of the term "Ceramics," *Journal*, July, p. 597, 1920. "The Meaning of 'Keramos' Once More," *Bulletin*, April, p. 114.

F. B. Ortman. *Jour.*, **6** [1], 49. Office: Councillor, California Section. Comm. on Divisions and Sections.

W. Gresham Owen. Born, Johnstown, Pa., January, 1887. High school education, supplemented by six years in three of Johnstown's business and technical schools. Various positions with Cambria Steel and Midvale Steel and Ordnance Companies (15 years). Asst. manager of sales, Haws Refractories Co., Johnstown, Pa. (5 years to date). Devoting time to study of raw and finished products. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Chairman, Comm. on Membership, Refractories Division.

W. G. OWEN

F. T. Owens. *Bull.*, **3** [1], 32. Office: Chairman, Heavy Clay Products Division. Comm. on Divisions and Sections.

C. W. Parmelee. *Jour.*, **5** [9], 215; *Jour.*, **6** [1], 40.

GORDON M. PELTZ

Office: Comm. on Data. Councillor, Chicago Section. Abstractor. Contribution: Co-author with John S. Lathrop, "Aventurine Glazes," *Journal*, July, p. 567.

A. R. Payne. *Bull.*, **3** [1], 32. Contribution: "Devitrification in a Lime-Flint Glass Tank," *Journal*, April, p. 271.

A. B. Peck. *Bull.*, **3** [1], 33. Office: Comm. on Divisions and Sections. Chairman, Detroit Section.

Gordon M. Peltz. Born, Philadelphia, Pa., October, 1893. M.E. degree, Columbia Univ., 1915. General design experience, the Surface Combustion Co., New York City (2 years). Furnace engineer, Corning Glass Works (5½ years to date). Member, A. S. M. E. Contribution: "A Graphical Chart for Determining Excess Air in the Combustion of Producer Gas," *Journal*, June, p. 437.

Forrest K. Pence. *Jour.*, **6** [1], 43. Office: Chairman, Comm. on Publications. Comm. on Research, Whitewares Division.

Stuart M. Phelps. Mellon Institute, Pittsburgh, Pa. Contribution: "Discussion on the Disintegration of Clay Refractories in Iron Blast Furnaces," *Journal*, September, p. 717.

James Gordon Phillips. Born, Piqua, Ohio, July, 1897. B.S., Ohio State Univ., Jan., 1921. M.S., O. S. U., 1924. U. S. Bureau of Mines, Ceramic Expt. Station, Columbus, Ohio, Jan., 1921–July, 1922. Ceramic chemist, Consolidated Gas Co., New York Coöperative fellowship, U. S. Bur. Mines and Ohio State Univ., 1923–24. Ceramic Chemist, Standard Oil Co., Elizabeth, N. J. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Abstractor.

J. G. PHILLIPS

Robert L. Porter. Born, Baltimore, Md., September, 1895. U. S. Naval Academy, 1917. Lieut. U. S. Navy. Contribution: Co-author with H. H. Norton, "The Method of Selecting Refractories for Marine Purposes of the Navy," *Journal*, July, p. 575.

Emerson P. Poste. *Jour.*, **6** [1], 53. Office: Councillor. Comm. on Divisions and Sections. Comm. on Standards (Tests and Products), Enamel Division.

E. E. PRESSLER

Amos. P. Potts. *Bull.*, **3** [1], 33. Office: Secretary, Heavy Clay Products Division.

Wm. H. Powell. Contribution: "Address on Terra Cotta," *Bulletin*, July, p. 255.

Eugene Edward Pressler. Born, Willow City, Texas, August, 1893. Chemical Eng., Univ. of Texas, 1921. Student, Ceramic Engineering, Ohio State Univ., 1921–22. Ceramic asst., U. S. Bur. Mines, Ceramic Expt. Sta., Columbus, Ohio, 1923–24. Junior Ceramic Engineer, Bur. Standards, Washington, D. C. Member, AMERICAN CERAMIC SOCIETY, 1923 to date. Contributions: "A Simple Brick Porosimeter," *Journal*, March, p. 154. "Comparative Tests of Porosity and

Specific Gravity on Different Types of Refractory Brick," *Journal*, June, p. 447.

W. S. Primley. Midland Terra Cotta Co., Chicago, Illinois. Member, AMERICAN CERAMIC SOCIETY, 1912—. Office: Comm. on Membership, Terra Cotta Division.

Ross C. Purdy. *Jour.*, **6** [1], 38. Office: General Secretary. Editor, *Journal*.

B. S. Radcliffe. Northwestern Terra Cotta Co., Chicago, Illinois. Member, AMERICAN CERAMIC SOCIETY, 1915—. Office: Secy., Terra Cotta Division. Comm. on Rules. Contribution: "Terra Cotta Body Investigation," *Journal*, November, p. 834.

Robert C. Rahn. Born, Chicago, Ill., June, 1894. B.S., Ceramic Engineering, Univ. of Ill., 1916. Research work in Ceramics, Western Electric Co., Hawthorn, Ill., 7 years. World war, 2 years. Manufacture of art pottery, Chicago, for the past year to date. Member, AMERICAN CERAMIC SOCIETY, 1918—. Office: Secretary and Treasurer, Chicago Section.

R. C. RAHN

L. B. Rainey. Fallston Fire Clay Co., Fallston, Pa. Member, AMERICAN CERAMIC SOCIETY, 1912—. Office: Question Box, Heavy Clay Products Division.

L. V. Reese. General Manager, Erie City Iron Works, Erie, Pa. Member, AMERICAN CERAMIC SOCIETY, 1924—. Office: Comm. on Research, Refractories Division.

Frederick H. Rhead. *Jour.*, **6** [1], 51. Office: Trustee, Art Division. Comm. on Exhibitions. Chairman, Comm. on Research. Comm. on Publications. Associate Editor.

William E. Rice. Bureau of Mines, Rollo, Mo. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Abstractor. Contributions: Co-author with R. A. Sherman and R. F. Lunger, "The Significance of Drafts in Down-draft Coal-fired Kilns," *Journal*, April, p. 255. Co-author with R. A. Sherman, "Determination of the Distribution of Heat in Kilns Firing Clay Wares," *Journal*, October, p. 738.

W. D. Richardson. *Jour.*, **6** [1], 32. Office: Comm. on Rules, Heavy Clay Products Division. Contributions: "Brick at less Cost," *Journal*, August, p. 614.

F. H. Riddle. *Jour.*, **6** [1], 43. Offices: Trustee, Whitewares Division. Comm. on Divisions and Sections. Councillor, Detroit Section.

L. E. Riddle, Jr. Sales Manager, Edgar Plastic Kaolin Co., Metuchen, N. J. Member: AMERICAN CERAMIC SOCIETY, 1923—. Office: Comm. on Membership, Heavy Clay Products Division.

F. G. ROBERTS

H. Ries. *Jour.*, **6** [1], 33. Office: Associate Editor. Comm. on Geological Surveys.

Frank G. Roberts. Maryland State Univ. Aerial mail service. Installation and service on PEMCO porcelain enamels and equipment, Porcelain Enamel & Mfg. Co., 1919–1924. Now assistant to vice-president, same Company. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Chairman, Membership Comm., Enamel Division. Vice-chairman, Baltimore-Washington Section.

James T. Robson. Born, Cleveland, February, 1895. B.S., Chemical Engineering, 1919, M.S., Chemical Engineering, 1920, Ph.D., 1923, Ohio State Univ. Instructor and professor, Ceramic Engineering, Ohio State Univ., 1919 to date. Service Engineer and Labora-

JAMES T. ROBSON

tory Director, C. B. Harrop Co., Columbus, Ohio, 1922 to date. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Comm. on Data, Refractories Division. Contribution: Gave valuable assistance in the detail work in the editing and compiling of the "Silica Bibliography." "Comparative Crazing and Chipping of Wet and Dry Process Cast Iron Enamels," *Journal*, July, p. 563. Co-author with J. T. Withrow, "The Dead Burning of Dolomite," *Journal*, January, p. 61, February, 141, March, 207, April, p. 300, May, p. 397.

W. F. Rochow. Born, Columbia, Pa., January, 1889. B.S., Pa. State College, Industrial Chemistry. Harbison-Walker Refractories Co., Pittsburgh, Pa. Member, AMERICAN CERAMIC SOCIETY, 1917—. Office: Comm. on Standards, Refractories Division.

DONALD W. ROSS

Donald W. Ross. Born, Crookston, Minn., January, 1885. B.S., Univ. of Washington, Seattle, Wash., 1910. Denny-Renton Clay and Coal Co., Seattle, Wash. General ceramics under A. V. Bleininger, U. S. Bur. Standards, Pittsburgh, Pa. (4 years). Ceramist, Findlay Clay Pot Co., Washington, Pa., 7 years to date. Member, AMERICAN CERAMIC SOCIETY, 1918—. Soc. Glass Technology. English Ceramic Soc. Offices: Comm. on Papers and Programs, Refractories Division. Comm. on Standards (Raw Materials).

G. Ross

Gustav Ross. Born, Oberhausen, August, 1876. M.E., Univ. of Liege, Belgium. Asst. professor, Univ. of Liege (1 year). Engineer, Rolling mills of Vieille Montagne works. Borbeck, 1 year and chief engineer (12 years). Gen. Mgr., Grillo Zink Smelting Works (8 years). Consulting engineer (2 years). Gen. Mgr., International Ore & Smelting Co., Saltillo, Mexico, 1922 to date. Contribution: "Fuel Oil Burning to Obtain the Highest Temperature Combined with Uniform Heat Distribution," *Bulletin*, April, p. 117.

HERBERT F. ROYAL

H. F. Royal. Was graduate with honors, Harvard College, 1917. General Electric Co., Lynn, Mass., July, 1917–Feb., 1918. Bureau of Standards, Pittsburgh, Pa., and Washington, D. C. in connection with problems concerning optical glass, Portland cement, magnesite cements and terra cotta, 1918–20. Chief testing chemist, N. J. State Highway Comm., Trenton, N. J., June, 1920–Oct., 1920. Champion Porcelain Co., Detroit, Mich., 1920 to date. Member, AMER-

ICAN CERAMIC SOCIETY, 1922—. Office: Secretary, Detroit Section.

THOMAS H. SANT

Thomas H. Sant. Born, Stoke-on-Trent, England, 1877. Was graduated from Orme School. Studied six years in France, Switzerland and Spain. Foreign Dept., Wenger's Ltd. (3 years). Entered into partnership with John Sant, 1904. President of John Sant & Sons Co., on death of John Sant, 1914. Member, AMERICAN CERAMIC SOCIETY, 1904—. Office: Treasurer, Pittsburgh Section since 1914.

Francis A. H. Schepers. Born, Maastricht, Holland, January, 1890. Attended various art schools in Europe. Research and factory control, Victor Chemical Works, Chicago, Ill. (5 years). Ceramist, American Terra Cotta and Ceramic Co., 7 years to date. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "The Pulsichrometer," *Bulletin*, February, p. 53.

FRANCIS A. H. SCHEPERS

Edward Schramm. Chem. Eng., Columbia Univ., 1909. Ph.D., 1913. Assistant chemist, Bureau of Standards, 1913–16. Research chemist, American Zinc, Lead and Smelting Co., 1916–18. Bridgeport Brass Co., 1918–19. Chemist, Onondaga Pottery Co., Syracuse, N. Y., 1919 to date. Member, AMERICAN CERAMIC SOCIETY, 1920—. Office: Abstractor. Comm. on Data, White Wares Division. Contributions: "Observations on the Properties of Clays and Clay-Grog Bodies," *Journal*, April, p. 282. "The Determination of Porosity of China by the Water Smoking Methods," *Journal*, June, p. 444.

EDWARD SCHRAMM

F. W. SCHROEDER

Frederic W. Schroeder. Born, Warrenton, Mo., 1899. A.B. degree, Central Wesleyan College, 1919. Fellowship in ceramics, Univ. of Wash., 1922–23. M.S. degree, Univ. of Wash., 1924. U. S. Bureau of Mines on helium investigation, 1919–22. U. S. Bureau of Mines, on refractory requirements for metallurgical furnaces. Contribution: "High Temperature Load and Fusion Tests of Fire Brick from the Pacific N. W. in Comparison with Other Well-known Fire Brick," *Journal*, January, p. 34. Co-author with Hewitt Wilson and C. E. Sims, "Artificial Sillimanite as a Refractory," November, p. 842, December, p. 907.

H. G. Schurecht. *Jour.*, **5** [9], 216; *Jour.*, **6** [1],

172. Office: Comm. on Data, Heavy Clay Products Division. Secretary, Pittsburgh Section.[1] Contributions: "Clay Sewer Pipe Manufacture, IV. The Influence of Different Salt Glazing Temperatures upon the Color and Gloss of Glazes Obtained on Clays with Varying Silica, Alumina and Iron Oxide Contents," *Journal*, June, p. 411. "The Influence of Varying Lime Content in Clays upon Some Properties of Salt Glazes Produced at Varying Temperatures," *Journal*, July, p. 539.

DONALD E. SHARP

Donald E. Sharp. Born, Corning, N. Y., 1896. Major study, physics, minor study, mathematics, Univ. of Wis. and Carnegie Inst. Tech. Assist. in Physics Dept., Corning Glass Works, 1914–17, under J. T. Littleton, Jr., chief physicist. Assistant in physics, Univ. of Wis., 1916–18. Ceramic Dept., U. S. Bur. Standards, 1918. Physicist and technical director, Spencer Lens Co., Optical Glass Plant, Hamburg, N. Y., 1918–21. Manager, 1921 to date. Member, AMERICAN CERAMIC SOCIETY, 1918—. Offices: Abstractor. Comm. on Standards (Tests) Glass Division.

J. B. Shaw. *Jour.*, **6** [1], 57; *Bull.*, **3** [2], 68. Office: Comm. on Data, Refractories Division.

Mary G. Sheerer. *Bull.*, **3** [1], 35. Office: Chairman, Art Division. Comm. on Divisions and Sections. Contribution: "The Development of Decorative Processes at Newcomb," *Journal*, August, p. 645.

T. A. SHEGOG

Thomas A. Shegog. Born, Dublin, Ireland. Royal College of Science, Ireland. Awarded Royal Scholarship. Was graduated with honors, specializing in silicate chemistry, 1886. Private research work in chemistry and lecturer on chemistry and physics in city of Dublin, Technical School, 1886–87. Associate, Inst. of Chemistry, Great Britain and Ireland, 1887. Fellow Chemical Society, London, 1887. Asst. chemist, Royal College of Sci., 1887–91. Fellowship, Inorganic chemistry, Inst. of Chemist, Great Britain and Ireland, 1891. County lecturer, chemistry and metallurgy, and director, technical instruction, Monmouthshire, 1891–98. Prof. Chemistry and Physics, Royal Veterinary College, Ireland, 1901–1904. Chemist and technical advisor, Arklow Terra Cotta Brick and Tile Co., 1904–07. Chief chemist, scientific advisor and technical expert, Cliffe Vale Potteries and Enameled Fireclay Works, Staffordshire, England, 1907–13. Studied ceramics Staffordshire Pottery School, 1907–09. Came to U. S., 1913. Chemist and consulting engr., Trenton Potteries Co., 1913–23. During war, research chemist for Butterworth-Judson Corp. and Calco Chemical Co. Ceramic engr., Sebring Pottery Co., and associate potteries, March 1923 to date. Member: Fellow, Amer. Inst. Chemists, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "Note on an

R. A. SHERMAN

[1] Resigned Sept. 1, upon removal to Washington, D. C.

Unusual Case of Warping of Flat Ware in the Glost Kiln," *Journal*, May, p. 377.

Ralph A. Sherman. Born, Oskaloosa, Iowa, 1896. A.B., Iowa State Univ. U. S. Bur. Mines, Pittsburgh Expt. Station, research on combustion problems and efficiency in use of fuels, 5 years. Survey of boiler furnace refractories to date. Member, AMERICAN CERAMIC SOCIETY, 1924—. Contributions: "Combustion in Kilns Burning Refractory Ware," *Journal*, March, p. 175. Co-author with R. F. Lunger and W. E. Rice, "The Significance of Drafts in Down-draft, Coal-Fired Kilns," *Journal*, April, p. 225. Co-author with W. E. Rice, "Determination of the Distribution of Heat Kilns Firing Clay Wares," *Journal*, October, p. 738.

R. R. Shively. Washington, Pa. Member, AMERICAN CERAMIC SOCIETY, 1919—. Office: Chairman, Membership Comm., Glass Division.

A. Silverman. *Jour.*, **6** [1], 61. Office: Comm. on Education, Glass Division. Councillor. Chairman, Comm. on Divisions and Sections. Contributions: Co-author with W. J. Sutton, "The Electrical Conductivity of Sodium Chloride in Molten Glass," *Journal*, February, p. 86. "Colloids in Glass," *Journal*, November, p. 795.

C. E. SIMS

Clarence E. Sims. Born, Chicago, Ill., July, 1893. B.S., Chemical Engr., Univ. of Ill., 1915. M.S., Metallurgy, Univ. of Utah, 1916. Electrolytic zinc with Anaconda Copper Mining Co., $2\frac{1}{2}$ years. Caustic soda and bleaching powder, Michigan Electrochemical Co., $\frac{1}{2}$ year. Research Division, Chemical Warfare Service, 1 year. Electrometallurgist, Bur. of Mines, Seattle, Wash., 3 years. Contribution: Co-author with Hewitt Wilson and F. W. Schroeder, "Artificial Sillimanite as a Refractory," *Journal*, November, p. 842, December, p. 907.

George Sladek. Born, Chicago, Ill., March, 1896. B.S., 1917, M.S., 1920, Univ. of Ill. Ceramic engineer, Beaver Falls Art Tile Co., Beaver Falls, Pa., June, 1920 to date. Member, AMERICAN CERAMIC SOCIETY, 1919—. Office: Comm. on Standards (Tests and Products), White Wares Division.

C. A. SMITH

Charles A. Smith. Born, Corning, Ohio, October, 1901. B.Cer.E., Ohio State Univ., 1923. Special student, Metallurgy, Lehigh Univ., 1923–24. Member, AMERICAN CERAMIC SOCIETY, 1921—. Honorary Societies, O. S. U. Plant experience during summers. Contribution: "The Manufacture of an Insulating Brick from Diatomaceous Earth," *Journal*, January, p. 52.

C. D. Smith. Simplex Engineering Co., Washington, Pa. Contribution: "Some Combustion Problems in Glass Making," *Journal*, August, p. 603.

H. H. Sortwell. *Bull.*, **3** [1], 36. Contribution: "The Bonding Effect of Ball Clays in Fired Bodies," *Journal*, February, p. 75.

Ira E. Sproat. *Bull.*, **3** [1], 36. Office: Comm. on Membership, White Wares Division.

H. F. Staley. *Jour.*, **6** [1], 42. Office: Abstractor. Comm. on Research, Enamel Division. Contribution: "Suggestions for Development in Enameling Technology," *Journal*, October, p. 719.

August Staudt. *Bull.*, **3** [6], 234. Office: Vice-president.[1] Comm. on Rules, White Wares Division.

W. J. Stephani. *Bull.*, **3** [1], 57. Office: Councillor, Terra Cotta Division.

H. H. Stephenson. Born, Bellary, India (Military Station), 1880. Munition chemist during war making explosives for English Navy. Research chemist for American Encaustic Tiling Co., Zanesville, Ohio. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Abstractor.

D. F. Stevens. *Bull.*, **3** [1], 37. Office: Comm. on Papers and Program, Heavy Clay Products Division. Representative, Comm. on Nominations.

H. R. STRAIGHT

Halver R. Straight. Born, El Paso, Ill., August, 1884. Mechanical Engineering, Univ. of Ill., 1907. General manager, Adel Clay Products Co., 1907 to date. President, 1922 to date. Member, Chairman, Standards Committee, Hollow Tile Assn. Contribution: "Planer Economies," *Journal*, July, p. 523.

Jasper L. Stuckey. Born, Princeton, N. Car., July, 1891. A.B., Univ. of N. Car., 1918. M.A. degree, 1920. Cornell Univ., 1921–24. Ph.D., Cornell Univ., 1924. Assistant in Geology, Univ. of N. Car., 1919–20. Instructor, 1921. Assistant in Geology, Cornell Univ., 1922–24. Assistant geologist, N. Car. Geol. and Econ. Surv., June, 1920 to Sept., 1921 and summers of 1922 and 1923. Geologist, N. Car. Geological and Economic Surv., July, 1924 to date. Contribution: "The Dehydration Temperature of Pyrophyllite and Sericite," *Journal*, October, p. 735.

J. L. STUCKEY

R. T. Stull. *Jour.*, **6** [1], 42. Office: Comm. on Research, Refractories Division. Contributions: Co-author with G. A. Bole, "Utilization of Georgia Kaolins in the Manufacture of Face Brick," *Journal*, May, p. 347. "Distribution of Kaolin and Bauxite of the Coastal Plain of Georgia," *Journal*, July, p. 513.

J. D. SULLIVAN

J. D. Sullivan. Born, Columbia Falls, Mont., February, 1900. B.S. and M.S., Chemistry, Univ. of Wash. Teaching fellow in chemistry at Univ. of Washington, 1 year. Analytical and research work with U. S. Bureau of Mines. Junior Physical Chemist, U. S. Bur. of Mines, Berkeley Station, to date. Contribution: Co-author with G. S. Tilley, "Note on the Rational Analysis of Clays," *Journal*, May, p. 379.

Willard J. Sutton Born, Hornell, N. Y., July, 1895. B. S., Ceram., Alfred Univ., 1917. Ph.D. Univ. of Pittsburgh, 1924. U. S. Army 1917–19. At present teacher of Chemistry, Fukien Christian Univ., Foochow, China. Member AMERICAN CERAMIC SOCIETY 1921—.

[1] Elected to fill vacancy caused by death of R. M. Howe.

American Chemical Society. Contribution: Co-author with A. Silverman, "The Electrical Conductivity of Sodium Chloride in Molten Glass," *Journal*, February, p. 86.

B. T. Sweely. *Jour.*, **6** [1], 45. Offices: Chairman, Baltimore-Washington Section. Comm. on Sections and Divisions.

C. F. Tefft. *Jour.*, **6** [1], 55. Office: Trustee, Heavy Clay Products Division.

D. M. Thorpe. General Refractories Co., Buffalo, N. Y. Member, AMERICAN CERAMIC SOCIETY, 1922—. Office: Comm. on Membership, Refractories Division.

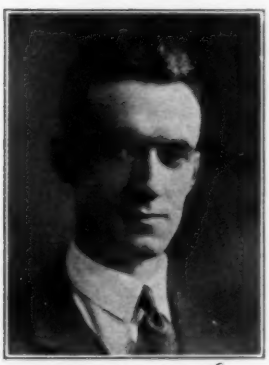
George S. Tilley. Born, St. George, Maine, November, 1881. A.B. and M.S., Harvard. Research, Carnegie Inst., General Electric Co., U. S. Bur. Stand. and U. S. Bur. Mines. Chemical Engr., Smith-Emery Co., San Francisco and I. F. Laucks, Seattle and Kobe, Japan. Associate Physical Chemist, U. S. Bur. Mines, Berkeley Station, research on methods for manufacture of alumina from clays and other aluminous materials of the U. S., to date. Contribution: Co-author with J. D. Sullivan, "Note on the Rational Analysis of Clays," *Journal*, May, p. 379.

L. J. TROSTEL

E. W. Tillotson. *Jour.*, **5** [8], 121; *Jour.*, **6** [1], 46. Offices: Associate Editor, *Journal*. Comm. on Research, Glass Division.

C. C. Treischel. *Jour.*, **6** [1], 56. Office: Secretary, White Wares Division. Comm. on Papers and Program. Comm. on Data.

Louis J. Trostel. Born, Galion, Ohio, December, 1893. B.Ch.E., Ohio State Univ., Chemist, Buckeye Steel Castings Co. Referee Chemist, British Ministry of Munitions. Chemical Engr., Standard Chemical Co., Research Engr., U. S. Bur. Mines. Research Engr., U. S. Bur. Chemistry. Chief Chemist, American Refractories Co. Chief Chemist, General Refractories Co., to date. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Chairman, Comm. on Data, Refractories Division. Contribution: "Note on a Comparative Test of Quicklimes for Silica Brick Manufactures," *Journal*, June, p. 452.



GUS M. TUCKER

Gus M. Tucker. Born, Chicago, Ill., May, 1893. Ceramist, Robinson Clay Product Co., Akron, Ohio, 1917–19. Vice-president, Ceramic Products Corporation, Old Bridge, N. J. and Ceramist, N. Y. Architectural Terra Cotta Co., Long Island City, N. Y., 1919 to date. Member, AMERICAN CERAMIC SOCIETY, 1917—. Office: Comm. on Coöperation, Terra Cotta, Division.

Karl Turk. *Bull.*, **3** [1], 39. Offices: Councillor, Enamel Division. Councillor, Baltimore-Washington Section.

W. E. S. Turner. Dept. of Glass Technology, The University, Sheffield, England., Contribution, "The Use of Boric Oxide in Glassmaking," *Journal*, May, p. 313.

Robert Twells, Jr. *Bull.*, **3** [1], 39. Contributions: "Handling and Storing Raw Materials to Produce Uniformity in a Body," *Journal*, February, p. 82. "Preparing and Spraying a Glaze Slip with Especial Reference to the Control of Various Operations," *Journal*, June, p. 465.

F. E. TWINING

Frederic E. Twining. Born, Croton, Ohio, May, 1874. Chemistry, Denison Univ., Granville, Ohio. General chemical analysis and engineering for 35 years. Special work on chrome and magnesite refractories during the war. Manager Twining Laboratories, Fresno, Calif. to date. Member, AMERICAN CERAMIC SOCIETY, 1919—. Office: Comm. on Papers and Program, Refractories Division.

Joel G. Wahlin. Born, McPherson, Kans., February, 1896. A.B., Bethany College, Lindsborg, Kans., 1917. Univ. of Ill., Grad. School, 1919–20. M.A., Univ. of Kans., 1922. Instructor, Bacteriology, Univ. of Kans., 1922–23. City Bacteriologist, Topeka, Kans. to date. Contribution: "Bacterial Growth in Enamel Slip," *Journal*, March, p. 160.

JOEL G. WAHLIN

F. W. Walker. *Jour.*, **6** [1], 34. Office: Councillor, Pittsburgh Section.

Thomas C. Walker Jr., Born, Wellsville, N. Y., March, 1898. B.S. (Ceramic Engineering), Alfred Univ. N. Y. Architectural Terra Cotta Co. Mosaic Tile Co. Central of Georgia Railway, in coöperation with the U. S. Bur. of Mines. Los Angeles Pressed Brick Co. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "Waste Heat Driers for Whiteware," *Journal*, August, p. 630.

THOMAS C. WALKER

E. W. Washburn. *Jour.*, **5** [7], 58; *Jour.*, **6** [1], 48. Office: Comm. on Research, Glass Division.

A. S. Watts. *Jour.*, **6** [1], 39. Office: Comm. on Standards, Definitions. Contribution: "Ball Clay Specifications," *Bulletin*, August, p. 288.

R. D. Wells. Factory Manager, The Floyd-Wells Co., Royersford, Pa. Member, AMERICAN CERAMIC SOCIETY, 1919. Office: Comm. on Rules, Enamel Division.

Fred A. Whitaker. Born, Ilkley, England, December, 1885. Haileyburg College, England. General engineering course, Inst. Tech., Charlottenburg, Germany. Ceramic course, Royal School of Ceramics, Bunzlau, Germany under Dr. Pukall. Experience in all phases of stoneware manufacture and erection of chemical plants in Europe. Works manager, chemical stoneware plant, General Ceramics Co., Keasbey, N. J.

F. A. WHITAKER

Member, AMERICAN CERAMIC SOCIETY, 1912—. Office: Abstractor.

Buhel E. Whitesell. Born, Salina, Pa., July, 1893. B.Cer.E., Ohio State Univ., 1922. Member, AMERICAN CERAMIC SOCIETY, 1923—. Ceramic Engineer, Kier Fire Brick Co., 1922 to date. Contribution: "A Dust Collecting System," *Bulletin*, March, p. 77.

B. E. WHITESELL

René V. E. Widemann. Born, Paris, France, October, 1881. Licensed Chemical Engineer. Chemist in the Production of Refractories (sanitary articles) since 1910. Engineer, chief of technical service of the factories of Compagnie Generale de Construction de Tours at Montrouge (Seine), France. Member, AMERICAN CERAMIC SOCIETY, 1922—. Contribution: "The Firing of Refractory Products of France," *Journal*, January, p. 29.

R. V. E. WIDEMANN

W. W. Wilkins. Member, AMERICAN CERAMIC SOCIETY, 1919—. Office: Comm. on Membership, Art Division.

A. E. Williams. *Jour.*, **6** [1], 53. Offices: Comm. on Data. Comm. on Standards (Tests and Products). Councillor, Glass Division.

C. E. Williams. *Bull.*, **3** [1], 42. Contribution: "Operating Conditions in the Open Hearth as They Affect Refractories," *Journal*, September, p. 681.

JAMES R. WITHROW

W. E. DORNBACH

W. S. Williams. Member, AMERICAN CERAMIC SOCIETY, 1919—. Contribution: "Comparative Service Tests of Gross Almerode and Domestic Clay Pots," *Bulletin*, November, p. 413.

James R. Withrow. Born, Philadelphia, Pa., August, 1878. B.S., Univ. of Pa., 1899. Ph.D., 1905. Research plant operation and consulting engineering work in chemical industries, 25 years. Head of Department of Chemical Engineering, Ohio State Univ. Contribution: Co-author with J. T. Robson, "The Dead Burning of Dolomite," *Journal*, January, p. 61, February, p. 141, March, p. 207, April, p. 302, May, p. 397.

Hewitt Wilson. *Jour.*, **6** [1], 111. Offices: Comm. on Geological Surveys. Secretary, Pacific Northwest Section. Contributions:

"High Temperature Load Fusion Tests of Fire Brick from the Pacific Northwest in Comparison with Other Well-Known Fire Brick," *Journal*, January, p. 34. Co-author with C. E. Sims and F. W. Schroeder, "Artificial Sillimanite as a Refractory," *Journal*, November, p. 842, December, p. 907.

Louis A. Wilson. Born, Pawtucket, R. I., July, 1892. B.S. Electro-chemistry, Mass. Inst. Tech., 1914. M.S., 1915. Chief of Testing Dept., N. J. Zinc Co., Palmerton, Pa. Member, AMERICAN CERAMIC SOCIETY, 1923—. Office: Comm. on Membership, Refractories Division.

H. G. Wolfram. *Bull.*, **3** [3], 99. Office: Secretary, Enamel Division. Contribution: "Effect of Zirconia in Enamels for Sheet Steel," *Journal*, January, p. 1.

W. G. Worcester. *Jour.*, **6** [1], 107. Office: Comm. on Geological Surveys.

A. S. Zopfi. *Bull.*, **3** [1], 44. Office: Chairman, Northern Ohio Section. Comm. on Divisions and Sections.

NOTES AND NEWS

MINUTES OF MEETING OF TECHNICAL COMMITTEE ON REFRACTORIES

Federal Specifications Board

Minutes of Meeting held on Thursday, Nov. 20, 1924, at 10 A.M. at the Bureau of Standards.

Members present:

L. H. Kenney, Navy Yard, Philadelphia, Pa.

M. E. Miller, War Dept., Washington, D. C.

H. G. Donald, Lieut.-Commander, United States Navy Fuel Oil Testing Plant, Philadelphia, Pa.

G. B. Vroom, Lieut.-Commander, United States Navy, Washington, D. C.

F. M. McGeary, Navy Dept., Washington, D. C.

E. L. Lasier, U. S. Shipping Board, Emergency Fleet Corporation, New York City.

N. F. Harriman, Vice-Chairman, Federal Specif. Board, Washington, D. C.

R. F. Geller, Bur. of Stand., Washington, D. C.

W. L. Pendergast, Bur. of Stand., Washington, D. C.

The following members were present as an advisory committee from the industry:

Ross C. Purdy, AMERICAN CERAMIC SOCIETY, Columbus, Ohio.

E. B. Powell, A.S.M.E., Boston, Mass.

L. C. Hewitt, Refrac. Mfgrs. Assn., St. Louis, Mo.

M. C. Booze, Refrac. Mfgrs. Assn., Pittsburgh, Pa.

J. S. McDowell, Refrac. Mfgrs. Assn., Pittsburgh, Pa.

The title of the Proposed Master Specification for Fire Clay Refractories was changed to Proposed Master Specification for Fire Clay Brick. Several other revisions of minor importance were made in the Specification and it was then adopted by unanimous vote and recommended to the Federal Specifications Board for approval. Interested parties are to obtain copies of the Master Specification from the Chairman of the Federal Specifications Board, Washington, D. C.

The Proposed Master Specification for Fire Clay was reconsidered and revised, particularly as regarded the screen test and bonding test. It was suggested that the

clays which are to be used with brick of Class SH 75 and H 75 should be tested at a maximum temperature of 1400°C for five hours and that clay used with lower grades of brick should be tested at a maximum temperature of 1350°C for five hours. It was also suggested that the method of applying the mortar and of laying up the joint should be revised so as to permit of forming a better bond.

Data presented regarding a screen test indicate that the present specification may be too rigid. It is expected, however, that the Government will continue to ask for fire clay, of which at least 96% will pass through a 20-mesh screen, until further data have been obtained which will show conclusively whether or not this is practicable. The chairman was requested to prepare the Proposed Master Specification for Fire Clay in revised form and distribute the same to members and advisory members for criticism and comment.

The Committee adjourned at 3:15 P.M.

R. F. GELLER, Vice-Chairman, F. S. B. Subcommittee on Refractories.

BUREAU OF STANDARDS NOTES

Preparation of Standard Specifications for Whiteware Pottery

A Master Specification for Vitrified Chinaware has been finally accepted and became effective on Nov. 5, 1924, as Federal Specifications Board Specification No. 243. This master specification for the purchase of vitrified chinaware has been evolved after an investigation covering a period of several years, in which manufacturers of vitrified chinaware through their Association have coöperated with the various Government departments using this material, and with the Bureau of Standards in which the laboratory work was carried out. The specification covers material known as thick china, hotel or rolled edge china, and medium weight china. The material, workmanship, and general requirements are given, as well as the detailed requirements in which there is defined in numerical values the resistance which this type of ware shall show to impact, chipping, and temperature change in order to be satisfactory. The specification further presents a detailed list of the trade size, actual size, maximum weight, and tolerance in size of every piece of ware which shall be used by the Government in its dining room service, enlisted men's service and hospital service.

When the preparation of this specification was undertaken by the Federal Specifications Board the Bureau of Standards was entrusted with the investigational work.

In the course of this investigation practically every make of vitrified chinaware manufactured in this country was tested, as well as several well known brands of chinaware from England, France, Germany, and Japan. The information obtained is considered as confidential, and the comparative value of the different brands cannot be supplied. It is believed, however, that the specification, a copy of which will be sent to interested parties on application to the Chairman, Federal Specifications Board, Bureau of Standards, Washington, D. C., will furnish sufficient data to be used as a basis for the purchase of vitrified chinaware for general use.

Problems Relating to Saggers

Chinaware to be successfully fired and glazed must be carefully placed in heat-resistant containers, known as saggers. These prevent the flame and soot present in the kiln from harming the ware. Saggers are also used in the tile, abrasive, and other clay industries where firing of the product requires great care. It is desirable to have these saggers made of clay of considerable strength and of good refractory quality.

The Bureau, in coöperation with the United States Potters' Association, is conduct-

ing an investigation which involves a geographical study of sagger clays and their classification according to properties. It has for its ultimate purpose the increase of the life of the sagger, thereby assisting the manufacturers who find the cost of saggers discouragingly high due to unsatisfactory service.

Approximately 10,000 routine tests made on the fifty-five clays included in this investigation have given the following information: The water of plasticity was found to range from 16 to 46% and the drying shrinkage from 10 to 20%. In the unfired state the porosity was found to vary from 24.5 to 50%, and the transverse strength ranged from 50 pounds per square inch to 380 pounds per square inch. The lowest softening point of these clays was equivalent to that of Orton cone 14, from which point they ranged to higher than cone 33. Specimens of each clay were subjected to five progressive firings ranging from 1150°C to 1310°C, with an increase of 40°C between succeeding firings and all of the clays except three were not overfired at the highest temperature. Clays fired to 1150°C showed a porosity ranging from 19.5 to 46.5%, and a volume shrinkage ranging from 1.9 to 16%, while after firing to 1190°C, the porosity varied from 14 to 46% and the volume shrinkage from 2.7 to 18%. After firing to 1230°C the porosity ranged from 8 to 40.8% and the volume shrinkage from 4 to 24.7%, while after the 1270°C firing the porosity varied from 1 to 38.5% and the volume shrinkage from 2.1 to 35.7%. The final firing (1310°C) produced a porosity varying from 8.8 to 39% and a volume shrinkage varying from 2.5 to 18.5%. Incomplete data covering the transverse strength tests indicate the strength to increase with succeeding firings up to 1270°C, while at 1310°C a large number of the clays show a decrease. The lowest fired transverse strength determined was 800 pounds per square inch, while the highest was 5300 pounds per square inch.

Coöperation by manufacturers permitted the repeated firing of a number of clays and mixtures of clays to as many as 26 burns under actual plant conditions. Specimens were returned by the potteries to the Bureau at intervals of three firings and progressive changes in their physical and chemical properties studied. Data collected indicate that repeated firings have very little effect on the properties of these clays.

A preliminary comparison of the results of the microscopic examination and the results of the physical tests have shown that the behavior of the clays depends to a certain extent upon the kinds and relative amounts of the minerals in the raw clays and the relative amounts of quartz, glass, and $3Al_2O_3.SiO_2$ crystals present in the fired body. After all preliminary data are collected, additional work will be done on the groups into which the clays are classified.

Use of Hydrated Lime in Portland Cement Mortar

It is quite common practice to add hydrated lime to Portland cement mortar, to improve its working qualities, while on the other hand Portland cement is added to lime mortar to hasten its set and increase its strength. The quantities of each material vary with the locality and the opinion of the user. Obviously there is a mix best adapted for given conditions. The determination of these mixes has been the subject of many investigations covering a number of years. An investigation has been completed at the Bureau dealing with the measurement of plasticity, time of set, yield, shrinkage, and tensile strength, together with a resumé of the literature upon these subjects. Many interesting points have been brought out, including:

(1) The richer the cement mortars, and the higher the percentages of lime which they contain, the more mixing water is required to bring them to a given consistency.

(2) A cement mortar to which lime has been added requires additional water, but this additional water increases shrinkage possibilities; therefore lime should be limited

in cement mortars where it is desirable to keep the shrinkage low. The principal advantages of the lime are that it increases workability, tends to prevent segregation and may reduce permeability if used in the proper proportion. Lime retards the set of cement mortars.

(3) The substitution of lime for an equal volume of cement always results in a decrease in strength. The substitution of lime for an equal weight of cement can not be expected to increase the strength of a cement mortar which is richer than 1:4.

(4) The desirable properties of cement-gaged lime mortar are short time of set, strength, elasticity, and workability.

A study of the literature indicates that: Inert, powdered admixtures possess positive merit for reducing permeability of mortars to water when applied to mortars that are not too rich; the strongest mortars may not always have the greatest adhesion; extra sand reduces adhesion of mortars; the strength of masonry depends upon the strengths of brick, mortar, and bond between mortar and brick.

Comparison of American and Foreign Clays as Paper Fillers

There are approximately from 200,000 to 300,000 tons of clay used annually in the paper industry of the United States. Because the larger portion of this amount is of foreign source and the clay resources of the United States are to a great extent undeveloped, the following investigation was made by the Bureau of Standards to ascertain the relative merits of American and foreign clays for use as paper fillers.

The term "clay" is applied to a variety of earthy substances, differing widely in their origin and composition and in many of their physical properties. The essential requirements of a paper-making clay are: Good color; low content of grit, mica, and other impurities; and uniformity. The first requirement must be possessed by the clay in its original state, but the percentage of impurities, such as grit and mica, can be lowered by washing and separation.

The paper section of the Bureau of Standards is equipped for making paper in a semi-commercial way and under practical mill conditions. The experimental paper-making equipment available for the work on clays consisted of a 50-lb. wood tub beater with manganese-bronze bars and plate, a small Jordan with iron bars, a 4-plate screen, and a 29-in. Fourdrinier machine with wire 33 ft. long and having two presses, nine 15-inch driers, a small machine stack of seven rolls, and a reel.

Commercial soda and sulphite pulps, and 8 representative clays, 5 American and 3 foreign, were used in this investigation. Preliminary runs established the best method of handling clay and determined constant factors.

The comparative study included tests for the amount of clay retained in the paper, the quality of the paper produced, and those physical properties of the clay (grit, etc.) that might affect the paper-manufacturing processes. Measurements for clay retention included analyses of samples taken at 13 different positions on the paper machine. The retention values obtained for the 8 clays (Nos. 1 to 5, domestic; Nos. 6 to 8, foreign) were: using 20% clay, 0.620, 0.611, 0.636, 0.630, 0.633, 0.655, 0.642, and 0.655, respectively; using 30% (runs varying per cent being made for only two clays), clay No. 3, 0.600, clay No. 6, 0.632; using 10%, clay No. 3, 0.720, clay No. 6, 0.748; and, using 5%, clay No. 3, 0.744, clay No. 6, 0.740.

Similar tests were also made on samples taken from the paper machine of a commercial mill in operation. The retention data agree with the results obtained in duplicate work in the experimental mill of the bureau. The commercial-mill test also included a study of white-water losses. Determinations made during the seven and one-quarter-hour test period show that, on a 24-hour basis, without a save-all there would have been

a loss of 3310 lbs. of clay and 2369 lbs. of pulp. By using the save-all there would be a loss of only 168 pounds of clay and 31 lbs. of pulp during that interval. The save-all not only increased stock recovery, by permitting the reuse of water with high concentration of stock for dilution purposes, but also effected a saving of thousands of gallons of water during the 24 hours.

Measurements made on physical properties of the clays failed to show any correlation between such properties and the amount of retention in paper, but the color and grit test slightly favored the foreign clays, although not sufficiently to justify the consideration of only these properties in the selection of clays. Physical tests made on the finished paper (bursting strength, finish, etc.) showed the results to be independent of the kind of clay added. Further details concerning this work will be found in Tech. Paper, No. 262 of the Bureau of Standards which may be obtained from the Superintendent of Documents at 15 cents a copy.

CALENDAR OF CONVENTIONS

Organization	Date	Place
AMERICAN CERAMIC SOCIETY (Annual Meeting)	Feb. 16–21, 1925	Columbus, Ohio
Am. Assn. of Flint and Lime Glass Mfrs. (Annual Meeting)	July, 1925	Atlantic City, N. J.
Am. Soc. for Testing Materials	June 22–26	Atlantic City, N. J.
Am. Concrete Institute	Feb. 24–27, 1925	Chicago, Ill.
Common Brick Mfrs. Assn.	Feb. 9–13, 1925	Chicago, Ill.
Hollow Bldg. Tile Assn.	Jan., 1925	Chicago, Ill.
Manufacturing Chemists' Assn.	June, 1925	New York City
Mining & Met. Society of America	Jan. 13, 1925	New York City
Natl. Assn. of Mfrs.	May, 1925	New York City
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March, 1925	Pittsburgh, Pa.
Natl. Assn. of Stove Mfrs.	May 13–14, 1925	New York City
Natl. Brick Mfrs. Assn.	Jan. 26–31	Washington, D. C.
Natl. Clay Products Industries Assn.	April, 1925	Chicago, Ill.
Natl. Lime Association.	May, 1925 (?)	
Tenth Exposition of Chem. Industries	Sept. 28–Oct. 3, 1925	New York City
Tile & Mantel Contractors' Assn. of America	Feb. 9, 1925	Louisville, Ky.
Western Paving Brick Mfrs. Assn.	Jan., 1925	Kansas City, Mo.

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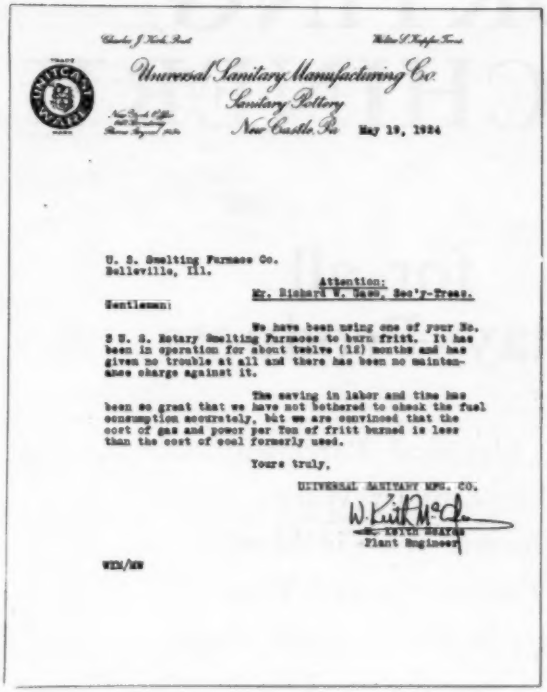

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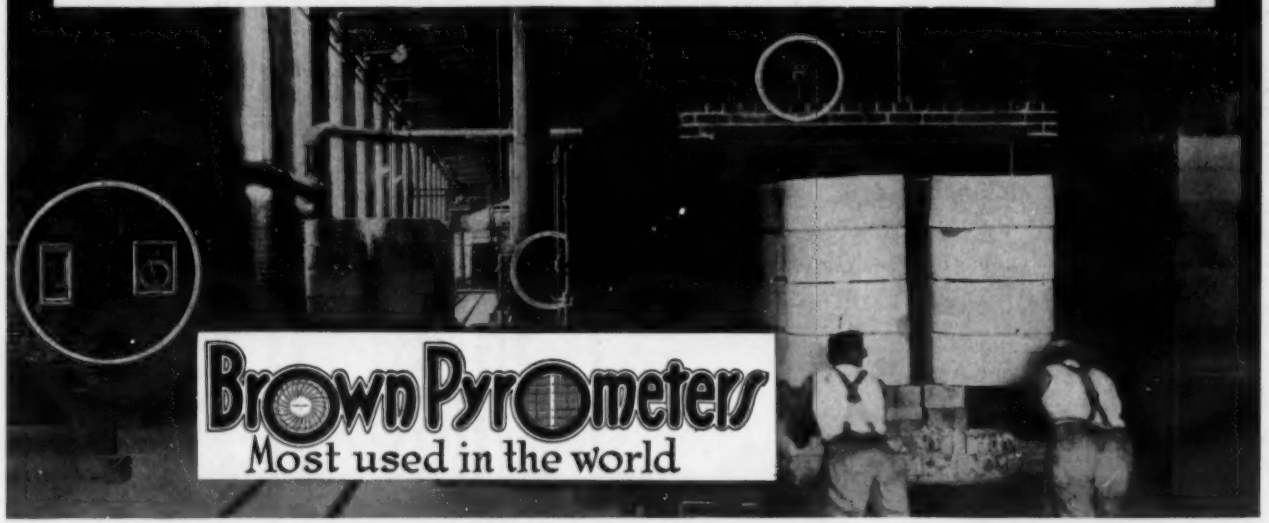

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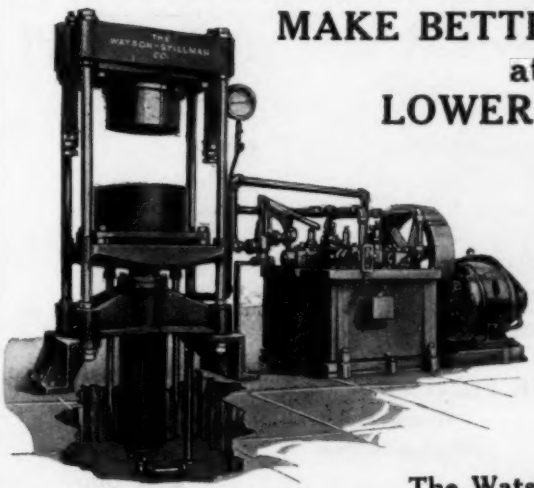

Showing a 50 Ton Sagger Press Outfit Complete equipped with dies for making Elliptical Sagger.

These Machines press saggers from solid wads of clay. Our sagger dies have no joints to work loose or open under pressure, this insures a homogeneous product and reduces to a minimum the losses in firing.

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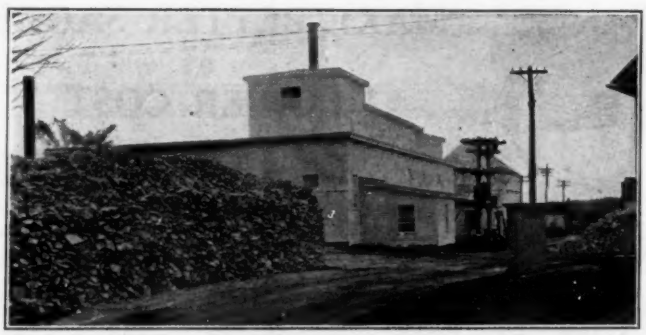

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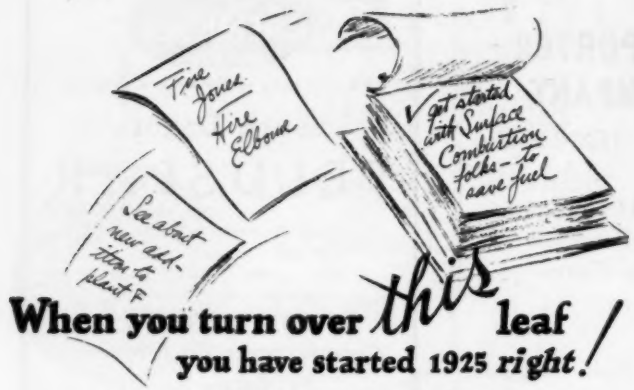

When you turn over *this* leaf you have started 1925 *right*!

"Fire Jones! Hire Elbome!"
"Start new system of records on parts"

PROBABLY you have a lot of little memorandums like these on your desk. Most of us have!

For with the New Year comes new ideas, bigger plans. Cobwebs are swept away, new methods are sought to increase output and decrease costs. It is the time when we most desire to "turn over a new leaf."

Start right by turning over this leaf!

Tear out all the troubles in your heat-treating equipment. Make it your immediate business to find out just what improvements can be made to your present system—

This you can by getting in touch with Surface Combustion folks—the largest and most broadly-trained family of heating engineers in the world. With Surface Combustion equipment you can,

Greatly reduce your fuel costs.
Increase your daily output.
Cut down your labor hours.
Lower your operating costs.
Improve the quality of your product.

The above facts have been proved many times over in the ten thousand installations made by Surface Combustion Company. Do this now—

Write, telephone or wire us to send one of our best Surface Combustion Engineers to talk over your heating problems with you. After looking over your equipment, he will make a report to you in portfolio form, showing you exactly what improvements can be made to your present system. This consultation service does not obligate you in any way.

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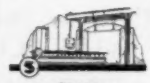
Utilization Division of the Combustion Utilities Corporation

8 classes of service

1 **Fuel Surveys**
Trained engineers make complete survey of your equipment and submit report in portfolio form.

2 **Plant Layout**
Laying out of floor plans; plotting in location of new or re-designed furnaces, showing where pipe lines shall go, etc.


3 **Complete Standardized Furnaces**
A complete line of furnaces for all industries on hand for quick installation.

4 **Complete Furnace Design**
Designing and building special furnaces, automatic firing equipment and controls, supervising erection and engineering details.

5 **Converting Existing Furnaces**
Re-designing, converting and repairing old-fashioned furnaces with automatic control, firing equipment, etc.

6 **Developing Specialized Furnaces**
For special requirements and peculiar plant conditions we develop special furnaces and combustion equipment.

7 **Stock Furnaces**
We keep on hand ready to ship, the largest and most complete line of stock furnaces in this country—a type for every need.

8 **Auxiliary Equipment**
Furnishing of all auxiliary equipment such as conveyors, pipe line units, blowers, etc. Each built to fit the needs of the installation.

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Announcement is made by the Newark Wire Cloth Company, Newark, N. J., that they have established a new branch office in the New England States. The address is: 66 Hamilton St., Cambridge, Mass., with Mr. John G. Loring in charge. A new factory of over 30,000 square feet ground area has just been completed on Verona Avenue in Newark. This company manufactures all varieties of wire cloth from a 4″ space of heavy wire down to the very finest meshes of 325 wires per inch.

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Here is a reliable guide along the pathway to the quickest burn—a guide that you can depend on for correct temperature information. And you will find that an Engelhard Pyrometer system has a way of delivering correct temperature information over a period of years at a cost for maintenance that will pleasantly surprise you.

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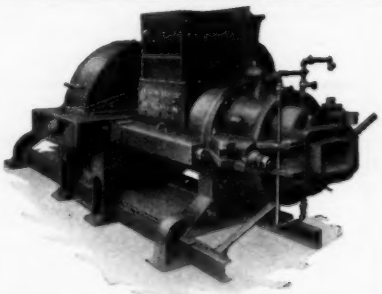

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"Hurricane" ceramic drying machinery has been developed to the point where big economies are possible that will pay for new installation well inside of the coming year. Our portfolio shows how this is done.

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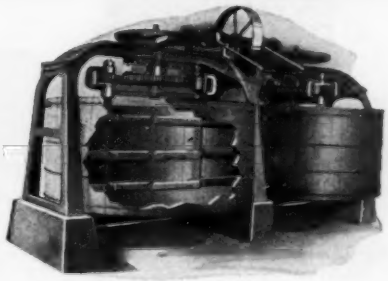

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A Post Card will bring you full particulars of this machine.

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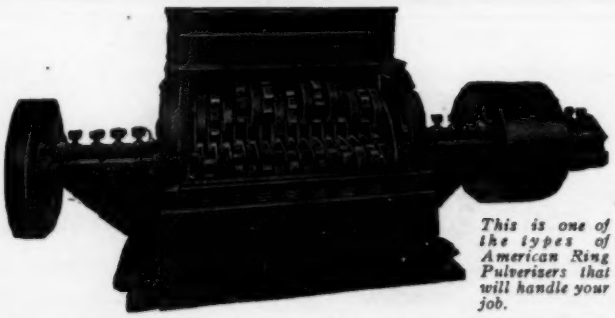

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When you are in the market for pulverizing equipment, include the American Ring Pulverizer in your investigations.

See how the ring method of crushing brings lower operating cost and an elimination of costly shut-downs.

We assure you that it does an unapproachable job on grog, glass cullets, coal and clay: but don't be convinced by our statement. Ask for the actual facts and figures based on the performance for scores of successful companies.

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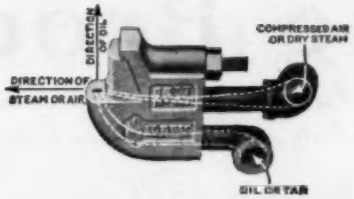

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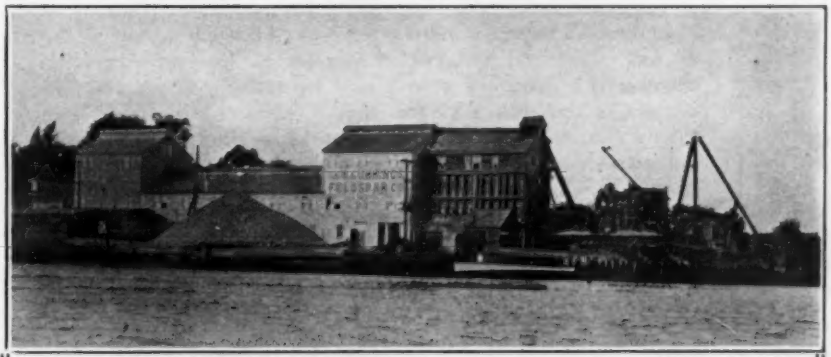

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How Carbo-Radiant Furnaces have improved enameling conditions at the Wolff Mfg. Corp.

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These furnaces have proved by performance the remarkable efficiency of the principle of heat by radiation which is the feature of the Carbo-Radiant.

They have already shown an increase in production—they have cut the oil fuel consumption practically in half over the old type of furnace—they have enabled the men to turn out better burned ware—clean, unspotted, uniform products.

The Carbo-Radiant Furnace is heated by means of combustion chambers made of Carbofrax, the Carborundum Refractory. The basis of which is Carborundum. From these chambers the heat radiates. There is no other commercial refractory material which even approaches Carborundum in its ability to transmit heat.

In these Carbofrax chambers there is a perfect combustion of the oil fuel. The heat radiation is so complete that the enameling chamber is of uniform temperature from door to back wall—so efficient is the heat radiation that there is no perceptible drop when doors are opened for charging or discharging. So quick is the radiation that it is possible to bring the furnace up to enameling heat in five hours. An improved system of oil and air feeds insures complete temperature control.

All combustion takes place in the Carbofrax chambers, there is no part of the furnace brickwork in contact with flame. Baffle walls and floors are of Carbofrax—practically no repair costs are to be considered.

The Carbo-Radiant Furnaces are designed, built, installed and guaranteed by The Carborundum Company.

The installation at the Wolff Manufacturing Corp. represents the last word in enameling furnace efficiency.

You should be interested in knowing more about it and how the Carbo-Radiant Furnace can improve your enameling conditions.

The Carbo-Radiant Furnace

The Carborundum Company

Performance

One of the batteries of Carbo-Radiant Furnaces

The other side of the furnace room

A close-up of one of the furnaces

Carborundum Refractories include Brick and Tile for Boiler and Furnace Settings—Muffles for Enameling Furnaces, Hearths for Heat-Treating Furnaces. Cements for all High Temperature Work

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They reduced breakage of enameled parts, secured a better quality finish, eliminated freight charges on the stove parts to and from the enameling jobber, besides cutting the actual enameling cost nearly in half—by installing a Pemco-approved enameling equipment and using Pemco porcelain enamels.

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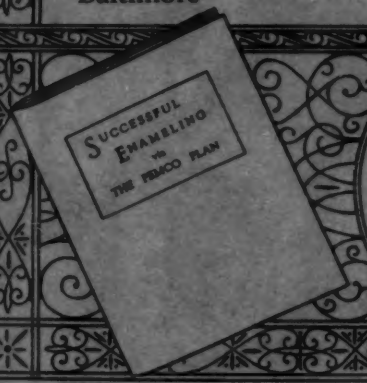

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